MINING CONGRESS JOURNAL

AMERICAN MINING CONGRESS

AMC

AUGUST 1960

MINING CONGRESS JOURNAL

VOL. 46 AUGUST 1960 NO. 8

CONTENTS

ARTICLES

DEPARTMENTS

ON OUR COVER

A 33-yd shovel installed at a Pittsburg & Midway Coal Mining Co. mine in Kansas in 1938 was the largest in the world at the time. Still in operation, it is stripping 45 ft of overburden from 17 in. of coal. See page 58 for The P & M Story commemorating the company's 75th anniversary.

Published Monthly. Yearly subscriptions, United States, Canada, Central and South America, $3.00. Foreign, $10.00. Single copies, $0.75. February Annual Review Issue, $1.25. Second class postage paid at Washington, D. C., and at additional Post Office, Lancaster, Pennsylvania.

featured

IN THIS ISSUE—and the AUTHORS—

ELECTRONIC COMPUTING ACTIVITIES

The Coal Division of U. S. Steel Corp. has been using an electronic computer in a variety of fields. Programs have been developed covering statistical quality control techniques applicable to washed coal production. In addition, the computer has been used for the development of production standards; the economic evaluation, comprehending price-quality relationships, of coals of various specifications; the processing of coal washability data, and the development of operating plan balances.

Roger D. C. Morris began his career with U. S. Steel Corp. in January 1941 as assistant industrial engineer for the Allentown Works of the American Steel & Wire Division. He was later transferred to Central Operations-Coal as district industrial engineer of the Coal Division's Frick District. In August 1953 he was promoted to his present position of assistant to the vice president, Operations-Coal.

ROCK BOLTING PRACTICES AT HOMESTAKE

Experience at Homestake demonstrates that rock bolting is a valuable means of support for it has eliminated much timbering—during 1958 the company used over 43,000 bolts. Nearly all development headings in loose or broken-up ground can be supported with rock bolts in conjunction with steel sheets, strips or wire mesh. In large stopes bolting has permitted more open cut-and-fill stoping with a corresponding decrease in square-set mining.

Clarence N. Kravig joined the geology department of Homestake Mining Co. in 1929 following graduation from the University of Minnesota. He became assistant mine superintendent in 1940 and mine superintendent in 1951. He is a frequent contributor to the technical literature and is active on the Underground Drilling Committee of the American Mining Congress.

EQUIPMENT NEEDS AND TRENDS IN MINING SEAMS OVER 48 INCHES THICK

In the past decade the coal industry has established a tremendous record of increased productivity and cost reduction, all the result of a rapid evolution in mining equipment and management techniques. Believing that the past is the best guide to the future, the author has closely examined the effect ten years of evolution has had on the components of the cost of coal production in an effort to determine the most likely areas for future cost reduction.

Edward H. Greenwald is a graduate of the University of Pittsburgh. Experience includes 14 years with Boone County Coal Corp. as mining engineer, chief engineer, assistant to the vice president, and general manager. Since 1956, when he joined the firm of Eavenson, Auchmuty & Greenwald as a partner, he has become intensely interested in the necessity of sound, objective planning in the mining field.

THE OUTLOOK FOR COMMERCIAL USE OF URANIUM

The United States, with large high-grade uranium reserves has real strength in its ability to supply the free world with atoms for power. Spector discusses problems to be surmounted in obtaining commercial nuclear power and gives an appraisal of factors that will influence the future course of the uranium industry.

A recognized world authority on nuclear energy, Dr. Norman A. Spector has over the past ten years directed the design and erection of chemical, metallurgical and nuclear facilities costing almost $1.5 billion. He is president of Vitro International and vice president of Vitro Corporation of America.

(CONTINUED ON PAGE 5)

(CONTINUED FROM PAGE 3) **IN THIS ISSUE—and the AUTHORS—**

THE WASHING CYCLONE

The "how and why" of a washing cyclone is spelled out in this interesting article. The report is based on the considerable amount of work that a major manufacturer has done on the theory and operation of the cyclone. Various combinations of feed and overflow and underflow orifices have been tested together with variations in coal feed sizes, media specific gravities, and feed pressures.

J. P. Matoney, chief engineer, Special Apparatus Division, Heyl & Patterson, Inc., joined the company's research and development department in 1948. Since then he has been instrumental in the development of many pieces of processing equipment marketed by the company and is credited with perfecting the H & P washing cyclone circuit.

ROCK MECHANICS

Disturbance of rock in any mining operation produces a multitude of reactions, some of which can be used to advantage while others raise serious problems. The author points out some of the problems facing researchers, discusses some of the practical values that can come from their studies and describes how some of the tools are applied to determine rock characteristics that form the basis of experiments.

Dr. John S. Rinehart is professor of mining engineering and director of the Mining Research Laboratory at Colorado School of Mines. He has studied both here and abroad and has had wide experience as a research scientist spanning a period of about 20 years. He is currently developing a center for graduate study and research in the field of rock physics.

THREE PRINCIPLES OF COMMINUTION

Studies of comminution theory as applied to crushing and grinding of rock have thus far failed to reveal the correct relationship between useful energy input and product particle size from a given size feed. The author presents a fresh approach to the basic principles in an effort to throw new light on this fundamental mineral process which has perplexed mineral scientists for 100 years.

The originator of the Third Theory of Comminution, Fred C. Bond is widely known as a leading authority in the fields of crushing, grinding and mineral dressing. He is presently an engineering consultant to the Processing Machinery Department of Allis-Chalmers Manufacturing Co.

VIEWPOINTS ON SAFETY

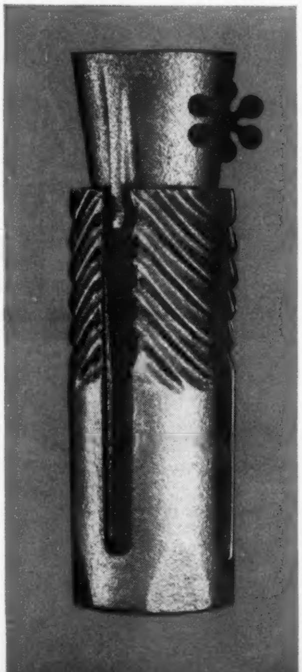
PART V—RESPONSIBILITY OF THE MANAGEMENT STAFF

Safety should be regarded as part of the responsibility for profitably running a company and to this end management staff should assist in teaching employes to work safely by implanting in them correct attitudes. In addition, management staff should keep abreast of the times in areas of labor relations, accident costs, selection of supervisors, and pertinent legislation.

As director of industrial and public relations at the Calumet Division of Calumet & Hecla, Inc., H. D. Stott is also intimately concerned with the safety program of his company, and is a past president of the Lake Superior Mines Safety Council.

Watch for the September issue which will carry a full preview of the 1960 AMC Mining Show, Las Vegas, Nevada, October 10-13


O-B Designs For Mining Men
RESULT:



Kolbe wheel moves 3,500 cubic yards of overburden per hour, discharges load more than 420 feet away.

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Standard Oil lubrication specialist Ken McDaniel (right) checks out lubrication needs with Cuba Mine superintendent Cecil Clayberg. This is work for which Ken is well equipped. He has six years' experience in such work plus an engineering degree from the University of Illinois. In addition, he has completed the Standard Oil Sales Engineering School.

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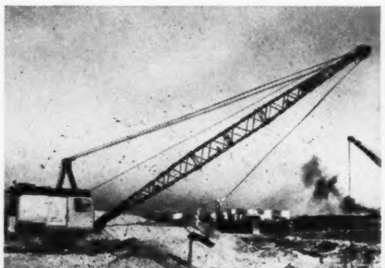
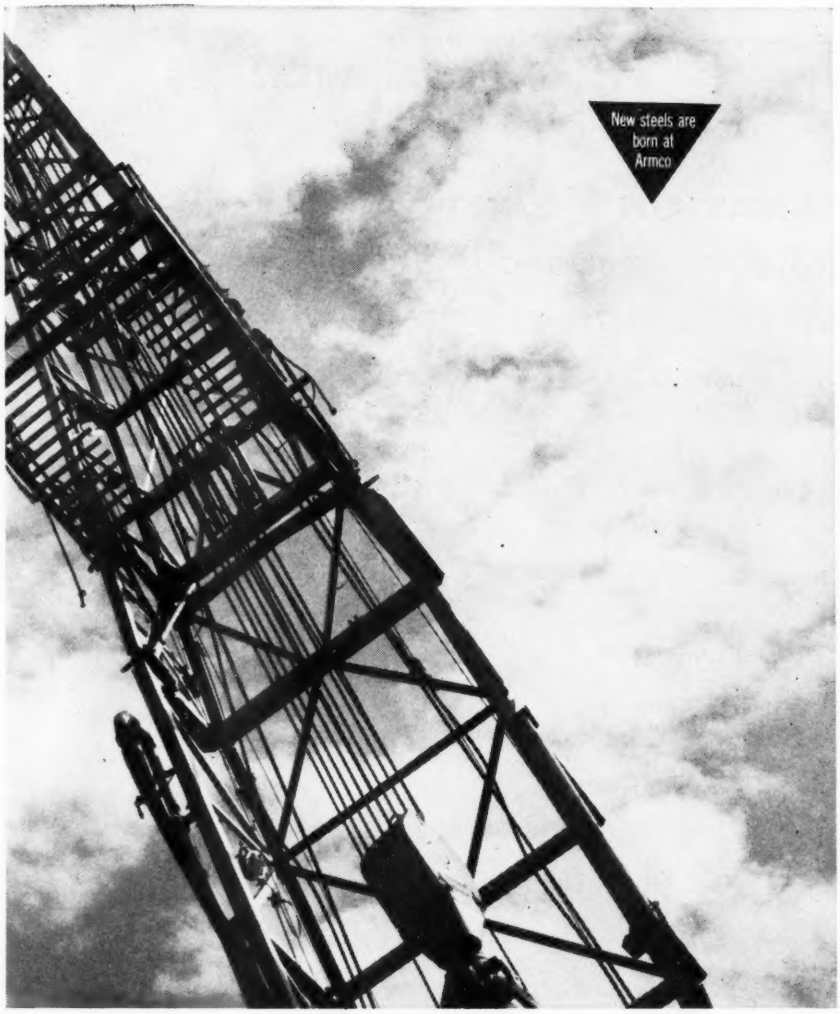
Tuffy Wire Ropes and Slings Are Tailored For Tough Jobs



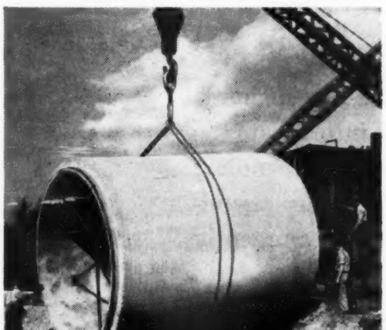
Tuffy Balanced Dragline Rope

Tuffy Balanced Scraper Rope

Tuffy Balanced Dozer Rope



Wire ropes travel hundreds of ton-miles on rotary oil drilling rigs lifting and lowering drill pipe and tools out of and into the hole. On the world's deepest oil well Tuffy Rotary Line handled the longest string of well casing ever run. The final live load totaled 700,000 lbs.



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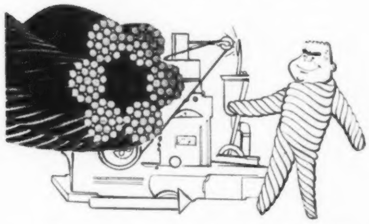
Tuffy® *Wire Rope* Tips

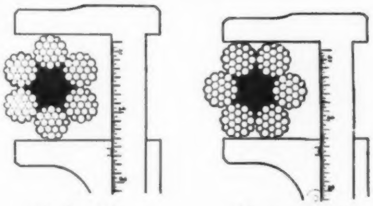
Money-Saving Information on the Use and Care of Wire Rope

Wire Rope is a "Machine" of Moving Parts



...and every part must fight destructive forces! A "look inside" a section of wire rope reveals a precision assembly of working parts. They are subjected not only to external and internal stresses, but also to heavy surface pressures and abrading. All these forces may be sustained while the rope is running at high speeds, and abruptly changing direction. That's why different uses require different constructions of wire rope.

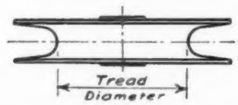
How to Measure Rope Diameter



Right Way ***Wrong Way***

There's only one right way: Use machinist's calipers, and be sure to measure the **widest** diameter. A slight shift of the rope in the calipers (shown at right above) might cause ordering an undersize rope.

How to Measure Tread Diameter



Easy, and important. Select the smallest sheave or drum to be used with the new wire rope, and measure actual diameter at lateral center (shortest dimension) of tread.

Would you like a copy of a booklet in which more than a score of Tuffy Tips like those above are reproduced. If so, write Union Wire Rope Corporation, [illegible] Manchester Ave., Kansas City 26, Missouri.

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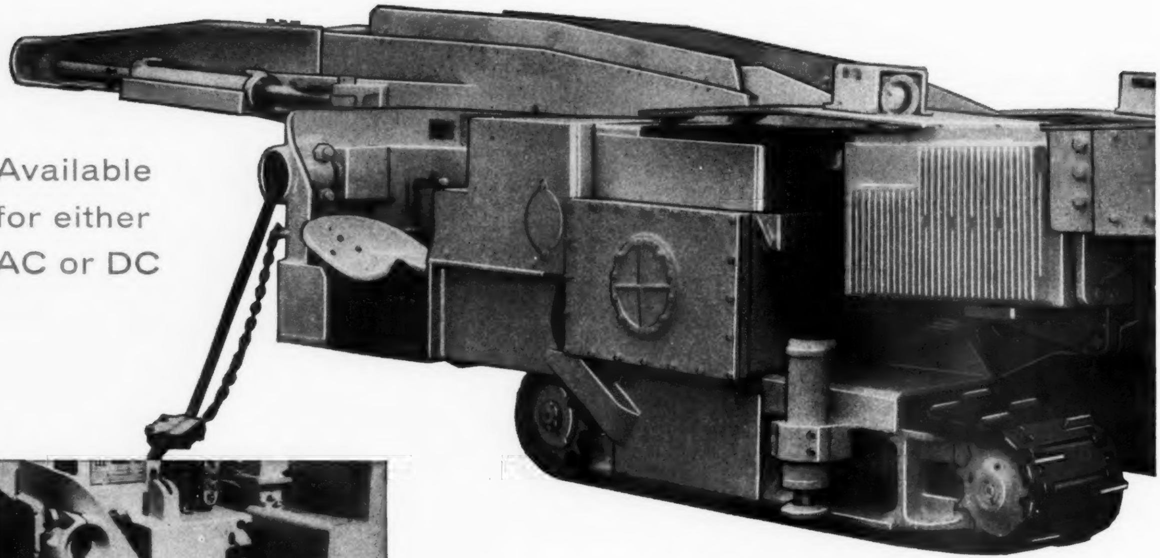
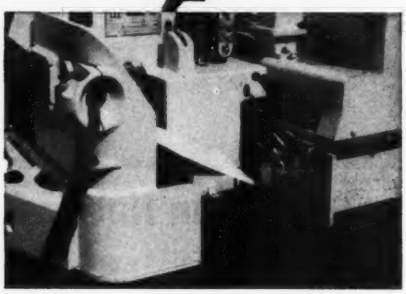


Available
for either
AC or DC



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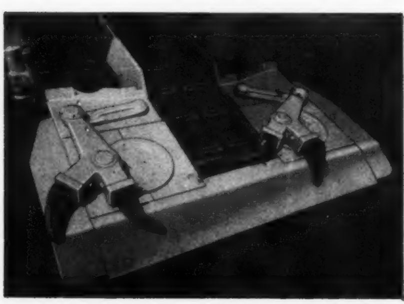

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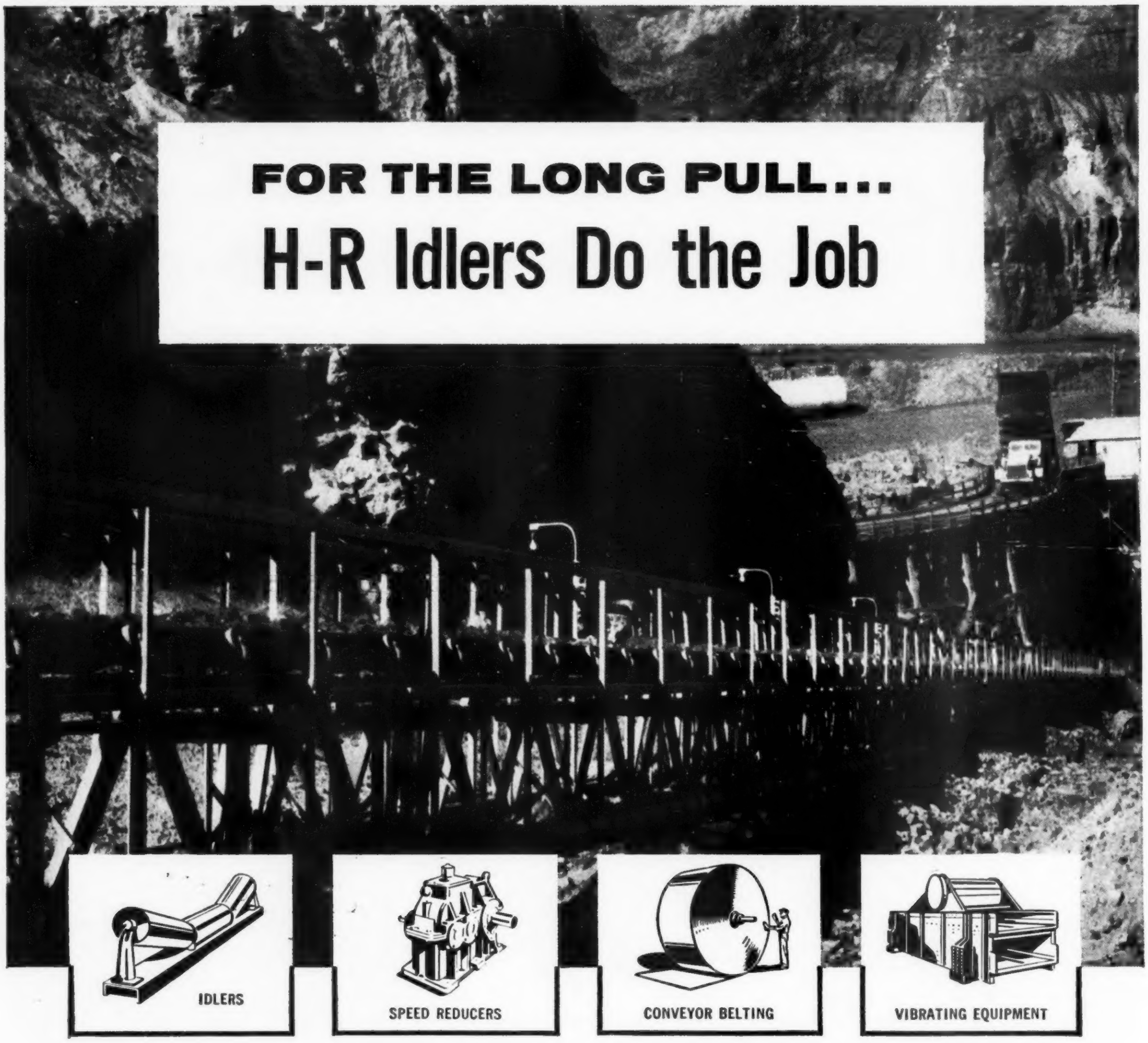
The exclusive "dual gathering arms" provide maximum reach and much better flow to the conveyor.

FOR THE LONG PULL...

H-R Idlers Do the Job



Iron ore begins the steep, long climb from mining pit to steel plant on this Hewitt-Robins conveyor system at a mine in northern Minnesota. H-R idlers used on this and other conveyor systems provide:

• **One-Shot Lubrication**—Application of grease gun at one grease fitting properly lubricates all six bearings through a single system. No vulnerable external piping.

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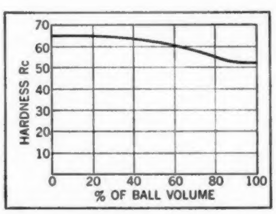
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60
50
40
30
20
10
0
20
40
60
80
100
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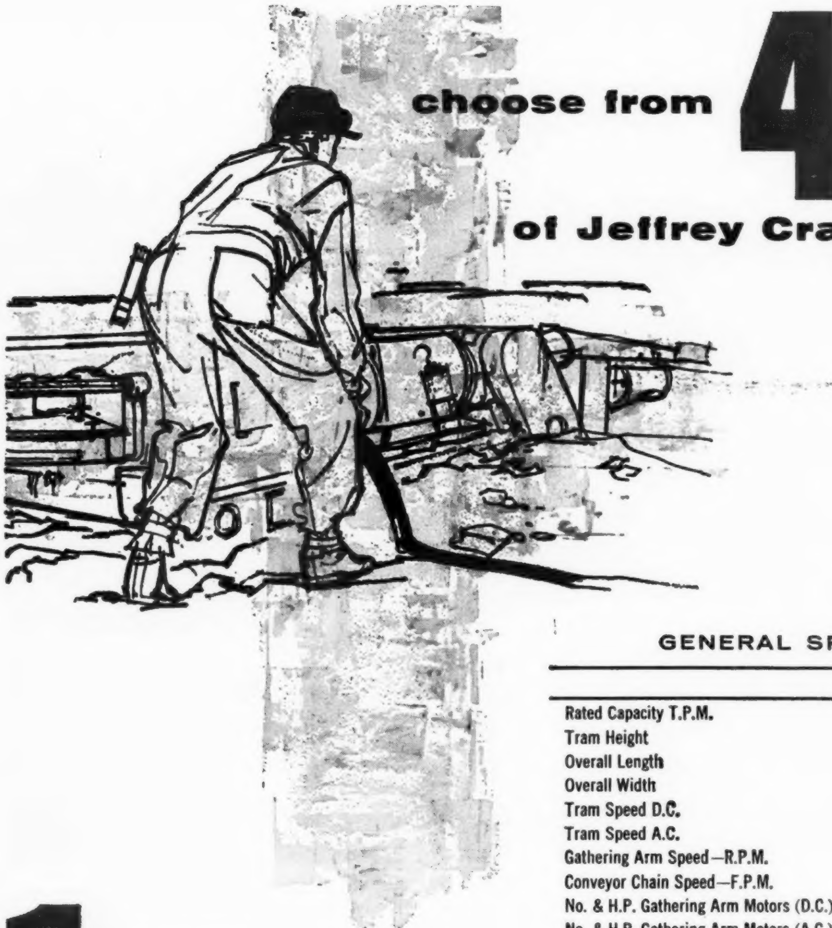

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Tram Speed D.C.	137	137	137	160
Tram Speed A.C.	85	85	85	160
Gathering Arm Speed—R.P.M.	55	55	55	53
Conveyor Chain Speed—F.P.M.	372	372	372	360
No. & H.P. Gathering Arm Motors (D.C.)	2—15	2—15	2—15	2—25
No. & H.P. Gathering Arm Motors (A.C.)	2—20	2—20	2—20	2—33
No. & H.P. Conveyor Motors (D.C.)	Uses Gathering Arm Motors			2—10
No. & H.P. Conveyor Motors (A.C.)	Uses Gathering Arm Motors			2—20
No. & H.P. Tram Motors (D.C.)	2—15	2—15	2—15	2—25
No. & H.P. Tram Motors (A.C.)	2—20	2—20	2—20	2—33/8.25
H.P. Pump Motor—A.C. or D.C.	4	4	4	8
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Editorials

MINING CONGRESS JOURNAL

ROBERT W. VAN EVERA, Editor

August 1960

A Golden Anniversary

Fifty years ago July 1 the U. S. Bureau of Mines was established by the Congress of the United States. We view this Golden Anniversary with particular pleasure, as the American Mining Congress led in the fight to establish a Federal Bureau of Mines.

In briefly reviewing the Bureau's accomplishments, it can readily be seen that the cause was worthy. During the ten years before the Bureau began its work, major coal mine disasters were claiming the lives of 364 miners a year. The average yearly disaster toll now is 32—still too high, but a better than ten-fold improvement nonetheless.

The Bureau of Mines has concentrated on accident reduction and improved health conditions in all types of mines. Its persistent work in safety education, first aid and mine rescue training, along with the safety programs of the mining companies themselves, has been a major force in the continuing reduction of accident frequency and severity that has characterized the entire industry.

Productive research in mining, metallurgy and fuels technology has added tremendously to the knowledge of those concerned with developing our mineral resources. For instance, Bureau scientists have played a prominent role in providing the nation with new metals such as zirconium, hafnium and titanium—whose special properties are vitally needed for our industrial and military might in this space age. They have demonstrated the feasibility, if not the economics, of mining oil from shale and the hydrogenation of coal. In joint efforts with the U. S. Geological Survey, the Bureau's mining and geological engineers have undertaken extensive exploration resulting in the discovery of commercial deposits of ores such as copper, lead, zinc and tungsten.

Over the years the Bureau has made many contributions to mining progress. It pioneered the technique of rock dusting, and made comprehensive studies to establish permissibility standards for explosives and underground mechanical and electrical equipment. Mine operators are familiar with the Bureau's part in the "rock bolting revolution" and in the development of reinforced and prestressed concrete supports—not to mention its more recent studies of numerous subjects such as hydraulic underground mining and rock mechanics.

The Bureau's program of supplying statistical data and economic analyses of domestic and foreign minerals has made available information of great value in appraising trends and evaluating the future of mineral enterprises.

These are but a sampling of the Bureau's many achievements but they do highlight a few of the benefits that have accrued to the mineral industry.

Changes in the industry have been manifold since 1910 and it is to the credit of those who have so ably guided the activities of the U. S. Bureau of Mines that it has kept constantly abreast of these changes—at the same time always advancing the original goals set forth by Congress 50 years ago.

For a Closer Look at Mining

The eyes of the mining world are being focused on Las Vegas—where the Metal Mining-Industrial Minerals Convention and Exposition of the American Mining Congress will be held October 10 to 13.

Las Vegas' new $5,000,000 Convention Center offers unsurpassed facilities for the largest "Mining Show" ever held. All types of mining, quarrying, and mineral treatment machinery and equipment will be exhibited by some 200 leading manufacturers. These exhibits, combined with the convention sessions on both policy and technical problems, afford a liberal education in "what's new" in the mining industry.

For full details, see our "preconvention issue" next month. Meanwhile, make your plans to be on hand when the Mining Show opens its doors on October 10.

Coal Research

With President Eisenhower's signature on July 7 of the Act establishing an Office of Coal Research, a bill that had held the close attention of the mining industry finally became law. While we do not want to fall into the trap of believing that research will provide a panacea for all of coal's problems, it seems reasonable to believe that a Federal research program can contribute a great deal to the industry and to the nation.

Much has been said of the small amount of money spent by the coal industry on research when compared to that spent by certain other industries. The plain fact is that most coal companies do not make enough money to plow any sizeable amounts back into research. And anyone who is acquainted with the high degree of competition that exists in the coal industry doesn't expect that the situation will change much in the near future.

The new Coal Research Program, which calls for the sponsoring and promotion of research in schools, research organizations and government agencies, will help to remedy this situation. By coordinating the research work of various groups and by allotting money for research projects under the guidance of an industry technical advisory committee, the Office of Coal Research can "develop new and more efficient methods of mining, preparing and utilizing coal," the goal set forth in the Coal Research Act.

By R. D. C. MORRIS
Assistant to the Vice President
Operations-Coal
U. S. Steel Corp.

Electronic computer aids large coal producer

In the:

- **Introduction of statistical quality control**
- **Development of production standards**
- **Evaluation of the price-quality relationships of coals of various specifications**
- **Processing of coal washability data**
- **Development of operating plan balances**

IN the interest of obtaining optimum coal quality and consistency of product, a new tool known as statistical quality control has been introduced to the coal operations of U. S. Steel Corp. The function of the statistical quality control technique is to indicate when significant quality changes have occurred to the washed coal products as measured from accepted quality standards. This is made possible through the use of a 650 digital computer which gives the information with great rapidity so that positive and timely decisions can be made concerning the operation of coal washers, the blending of coals, and the burdening of blast furnaces.

Through analysis of washed coal quality requirements it has been determined that quality data should be made available reflecting daily, weekly, and monthly performances against accepted standards for moisture, ash and sulphur. Various statistical tests are performed on the data, which result in an indication of whether the analyses are consistent for practical purposes, or significant departures are being experienced for which positive corrective action must be taken.

Bias and Unbias in Statistical Analysis

The development of these quality control reports is of much interest, and this article will review the theories behind the calculations so that there will be a general understanding of the interpretation of the statistical results.

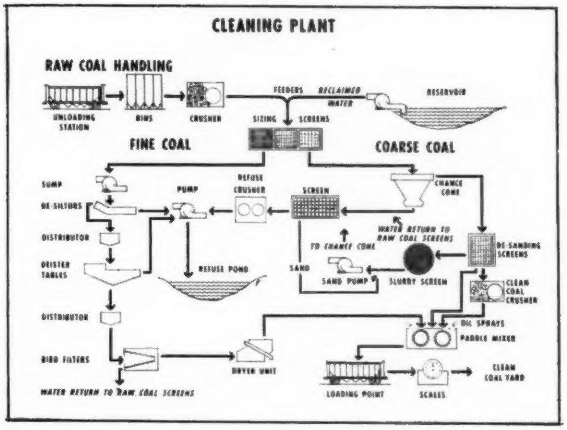
First, a definition of two terms will be in order—"unbiased" and "biased"—which refer to the data that will be subjected to statistical analysis. The meaning of "unbiased" can be gained by visualizing a coal washer receiving over a considerable period of time a raw coal feed that is reasonably consistent as far as mix, size and quality are concerned; also, operation of all of the washer facilities is constant. A product that is produced under these conditions would be considered as having been produced under unbiased conditions, and the analyses that are made of the samples would follow a normal distribution pattern. Sixty-eight percent of the analyses would fall in the area on each side of the mean; a cumulative 95 percent would fall in the first two areas on each side of the mean; and a cumulative 99.8 percent of the analyses would fall in the three areas on both sides of the mean.

The distribution of the sample results of unbiased data that the writer has reviewed results from the fact that there are, under accepted industrial sampling procedures and analysis, inherent errors that affect the resultant data. By inherent errors, the author means lack of precise accuracy to which any industrial analysis is subject, and the term should not be interpreted as meaning mistakes.

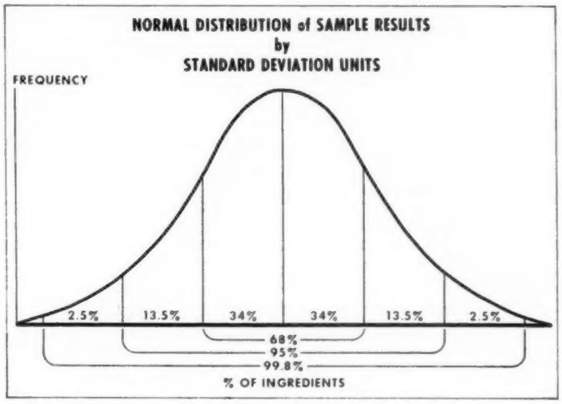
Now, on the other hand, biased data would result from changes in mine mix, washability characteristics or quality of the raw coal feed and/or changes in the washer processes within a sampling period. The sample results of coal produced under these considerations would not necessarily result in analyses following a normal distribution curve. Unbiased data results in one type of distribution of sample analyses, while biased data would result in a different type of distribution. (The term "biased" is used in this reference to describe an operation or testing procedure that has been performed under nonstandard conditions, and is not the ASTM definition, which defines bias as a systematic error that is con-

sistently positive or negative.)

Thus, there are two forces at work in the distribution of sample results. This is true not only of coal washers but of any commercial or industrial operation. In one case the sample results have a predictable distribution for identical products, and in the other case the distribution of results is affected by a non-standard mix of coals, operation of the washer, sampling procedures, or many other possible deviations from standard. Thus, when one observes the distribution of sample data, one cannot be sure whether the results are representative of identical product or the result of non-standard operating conditions unless one resorts to statistical analysis. Recognizing the fact that one would expect to find variable sample results for identical product, one may be tempted to assume that a shipment is not off standard when in reality it is. Making such an assumption is not justified unless statistical analysis indicates that the variation of sample results is within the predictable or expected distribution of results for identical product. In other words, one would be considerably safer to statistically determine whether the variation from the accepted standard is significant or not significant. Statistical quality control techniques seek out and separate the unbiased results from the biased.



Figs. 1 and 2. The coal washer (above) receives a raw coal feed that is reasonably consistent as far as mix, size and quality are concerned; in addition, operation of all of the washer facilities is constant. In this case, the resulting product would be considered as having been produced under unbiased conditions, and the analyses that are made of the samples would follow a normal distribution pattern (below)

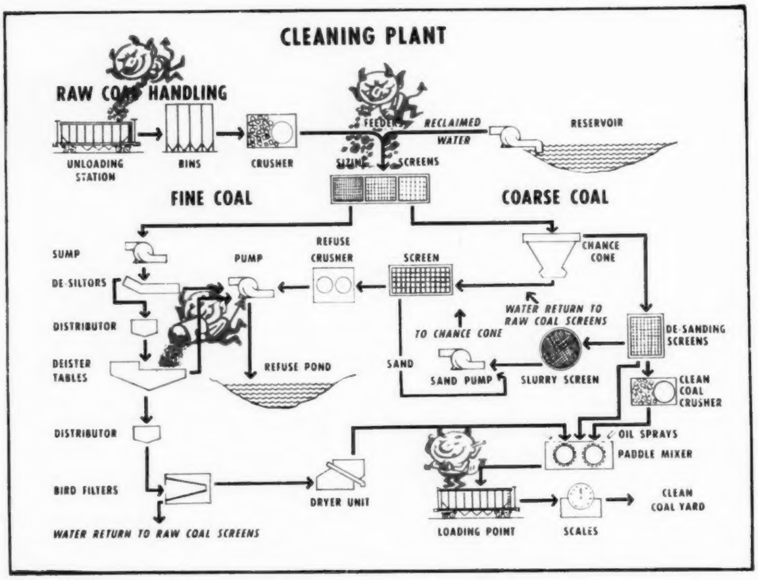


Standard Deviation—A Measure of Distortion

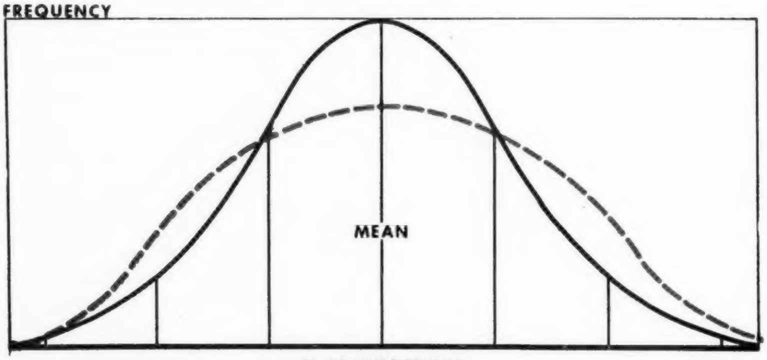
In the application of the quality control program for U. S. Steel's Coal Division, certain basic quality and quantity data and various indices are required on a daily, five-day and monthly basis. Within each of these time groups the application of the quality control techniques will incorporate the tons of coal; total number of units—barges, railroad cars; and the averages for ash, sulphur, moisture and coking test as determined from accepted ASTM sampling procedures. From these data will be developed statistical measures of quality performance. These measures are reflected in such calculations as standard deviation; conformity of current sample analyses for ash, sulphur and moisture around standard means; "t" test; "F" test; and coefficient of variation.

The calculation of the standard deviation is a calculation that is also involved in the remaining statistical tests. It is calculated by use of the formula given in figure 5. Standard deviation is a measure of the distortion of sample results around a mean and is sometimes called "scatter." Actually, it is not too difficult to visualize. It can be shown that the sample results of unbiased data (see figure 2) will be distributed around a mean in such a manner that 68 percent of the results will fall within plus or minus one standard deviation unit, 95 percent will fall within plus or minus two standard deviation units, and 99.8 percent will fall within plus or minus three standard deviation units. Based on this hypothesis, it is also concluded that analyses resulting from unbiased coal samples will follow this distribution when the sampling is performed according to ASTM specifications. If they do, management has assurance that any variation in sampling results is probably due to the inherent error in the accepted sampling procedures and that the entire day's, week's, or month's production can be considered to be at the standard current mean value for ash, sulphur or moisture. If the sample results do not follow the normal distribution, there is reason to believe that significant variations are taking place, and the consistency of the product is subject to question.

Suppose, for example, that the fact has been established that the distribution of current sample data falls within the normal distribution around the current mean. Actually, this is not enough information to tell management that its product has a homogeneous consistency on a continuing basis; that is, from day to day, week to week and month to month. Therefore, it is necessary to have a means of determining the relationship of current sample data to some standard distribution around a standard mean. As used in this description, the word standard should not be confused with standard analyses or specifications that are built into the cost system. Rather, U. S. Steel is interested in the consistency of the actual product that is being shipped. Thus, for comparison purposes with current data, it has been determined that the previous month's actual results should become the standards for the current month. Of course, should there be an adverse trend during a month, the results of the month would have to be



Figs. 3 and 4. Biased data would result from changes in mine mix (above), washability characteristics or quality of the raw coal feed and/or changes in the washer processes within a sampling period. The sample results of coal produced under these considerations would not necessarily result in analyses following a normal distribution curve, but one might get a distribution (below) similar to the one that is superimposed on the normal



adjusted to reflect more representative standards. Thus, the analysis of the distribution of current sample data is made in relation to last month's means and standard deviations (see figure 6), and from such a comparison one can recognize significant trends.

For example, the monthly performance figures for sulphur in table I show only 76.84 percent of the expected number of occurrences fell within plus or minus one standard deviation unit from the mean. That is, only 76.84 percent of the expected 68 percent or 52 percent of the observations fell within plus or minus one standard deviation unit, 89.31 percent fell within plus or minus two standard deviation units and 98.63 percent fell within plus or minus three standard deviation units from the mean. When measured against the previous month's performance, the current month shows obvious variability.

Further statistical tests will tell management more about this departure from last month's results. These tests are necessary to completely relate the facts. The company would like to know what is happening to its averages or current mean values for ash, sulphur and moisture when compared to last month, and it would also like the facts concerning the standard deviations in the two periods. Were the company to use standard deviation only, it would know nothing about the significance of a change in mean values from month to month. As shown in figure 7, the shape of the two curves indicates identical standard deviations, while the mean values are significantly different.

Testing Plant Variations and Conformity

Conversely, were the company to use mean values only, it would have no knowledge of the significance of variability. As illustrated in figure 8, the shape of the two curves indicates identical mean values, while the variability in the one case is normal and in the other is quite biased.

Taking the problem of the current versus the standard mean values first, management wishes to determine whether an observed difference between the standard daily, five-day, and monthly means and the current means for the same time periods are significant. That is, do these differences indicate a real change in the average analyses for ash, sulphur, and moisture, or are the observed variations within expected tolerances.

To make these determinations, a statistical test called the "t" test is utilized (figure 9). The purpose of displaying this formula and other formulae is not to follow the mathematics involved, but to give the reader an idea of the type of calculations that can be handled with ease by a 650 computer. All the formulae that are displayed are handled within a single program with results calculated in five minutes for a day's productivity data from one washer.

Continuing with the discussion of the "t" test, the calculated values of "t" are referred to appropriate tables to determine, for the number of observations or sample results involved whether the observed differences are significant or not significant (table II). Generally speaking, significant changes in the ash, sulphur and moisture are reflected in relatively large values of "t". These values of "t" mean that the average has changed significantly, which is not surprising in light of the result of the current distribution of individual samples around the previous month's mean. Thus the company has established that in addition to excessive sulphur variability in comparison with last month's results, there is also a significant change in the average sulphur between the two periods.

The calculation of the "F" test comprehends the use of variance (figure 10) which is the square of the standard deviation. The "F" test (figure 11) in effect measures the degree of conformity of the current standard deviation results with the standard

Table I. Percent distribution by standard deviation units (performance). Note how the current month shows obvious variability when measured against the previous month's performance. For example, referring to the monthly performance figures for sulphur, only 76.84 percent of the expected number of occurrences falls within plus or minus one standard deviation from the mean

	Standard Deviation Units ± 1	± 2	± 3	Over 3	Under 3
Daily Moist.	92.51	104.77	100.27		
Daily Ash	131.06	104.77	100.27		
Daily Sulp.	38.55	77.20	100.27		
5 Day Moist.	98.11	104.77	100.27		
5 Day Ash	122.99	100.81	100.27		
5 Day Sulp.	74.62	87.96	98.38	2	
Month Moist.	91.25	101.33	100.27		
Month Ash	117.66	99.61	100.27		
Month Sulp.	76.84	89.31	98.63	2	

Table II. Current average analyses and the "t" test. Generally speaking, significant changes in the ash, sulphur and moisture are reflected in relatively large values of "t"

	Date	Coal Type	Total Barges	Tons	Ave.	Current Error "t" Test
Daily Moist.	5/18/59	1	19	17,466	7.57	2.55 –
Daily Ash					7.35	0.56
Daily Sulp.					1.72	7.35
5 Day Moist.			106	97,467	7.72	2.86 –
5 Day Ash					7.20	4.99 –
5 Day Sulp.					1.70	10.75
Month Moist.			122	112,153	7.70	3.15 –
Month Ash					7.18	5.50 –
Month Sulp.					1.69	8.38

deviation results of the previous month. In other words, the company has a measure of the degree of current variability of its product around current means when compared with the degree of last month's variability around last month's means. A value of 1 for the "F" test indicates that there has been no change in degree of variability. Table III shows a value of 1 for sulphur for the monthly "F" test, which means there is no more variability than last month, but when interpreted in light of other information that the company has gained, it knows that the variability is around an entirely different mean value. The results of the statistical analysis concerning sulphur indicates that corrective action should be taken to restore the sulphur content of the washed coal to an acceptable level.

The coefficient of variation (figure 12) is the percentage that the standard deviation is of the accepted standard mean value for ash, sulphur and moisture. This coefficient is an interesting figure in that it is indicative of the tolerances within which washer practices are operating. For example, table IV shows that the monthly coefficient of variation for moisture is 7.13 percent, representative of one washer. This means that the standard deviation of moisture samples is 7.13 percent of the mean. At another washer in an entirely different location, the comparable figure is 9.78 percent and at a third washer 3.78 percent. There is far less spread in moisture samples at Washer No. 3 than at either of the other two. Again, referring to the table, note that the coefficient of variation for ash is 2.50 percent and for sulphur 2.87 percent. These results indicate that there is

Table III. Statistical tests on current average analyses. A value of one for the "F" test indicates that there has been no change in degree of variability

	Date	Coal Type	Total Barges	Tons	Ave.	Current Error "t" Test	Stand. Dev.	Current Var. Rat. "F" Test	Coeff. of Var.
Daily Moist.	5/18/59	1	19	17,466	7.57	2.55 –	0.47	0.81	6.14
Daily Ash					7.35	0.56	0.15	0.59	2.09
Daily Sulp.					1.72	7.35	0.03	0.68	1.93
5 Day Moist.			106	97,467	7.72	2.86 –	0.50	0.86	6.46
5 Day Ash					7.20	4.99 –	0.17	0.57	2.31
5 Day Sulp.					1.70	10.75	0.04	0.80	2.35
Month Moist.			122	112,153	7.70	3.15 –	0.55	0.90	7.13
Month Ash					7.18	5.50 –	0.18	0.51	2.50
Month Sulp.					1.69	8.38	0.05	1.00	2.87

Table IV. Statistical tests on current average analyses. From figures such as the coefficient of variation, operating management can set additional standards of operating performance

	Date	Coal Type	Total Barges	Tons	Ave.	Current Error "t" Test	Stand. Dev.	Current Var. Rat. "F" Test	Coeff. of Var.
Daily Moist.	5/18/59	1	19	17,466	7.57	2.55 –	0.47	0.81	6.14
Daily Ash					7.35	0.56	0.15	0.59	2.09
Daily Sulp.					1.72	7.35	0.03	0.68	1.93
5 Day Moist.			106	97,467	7.72	2.86 –	0.50	0.86	6.46
5 Day Ash					7.20	4.99 –	0.17	0.57	2.31
5 Day Sulp.					1.70	10.75	0.04	0.80	2.35
Month Moist.			122	112,153	7.70	3.15 –	0.55	0.90	7.13
Month Ash					7.18	5.50 –	0.18	0.51	2.50
Month Sulp.					1.69	8.38	0.05	1.00	2.87

Fig. 5. Standard deviation formula

$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}}$$

Note: The above formula was used in this discussion because of its simplicity and ease of understanding. The actual formula that is built into the 650 computer program is as follows:

$$s^2 = \frac{n\left[\sum wp^2 - (\sum wp)^2\right]}{(n - 1) \cdot (\sum w)^2}$$

$$s = \sqrt{s^2}$$

Where:

n = number of sampling units
$\sum w$ = sum of the weights of the sampling units
$\sum wp$ = sum of the products of the weights times the lab values for each sampling unit
$\sum wp^2$ = sum of the products of the weights times the square of the lab values for each sampling unit

CURRENT DISTRIBUTION vs. STANDARD DISTRIBUTION

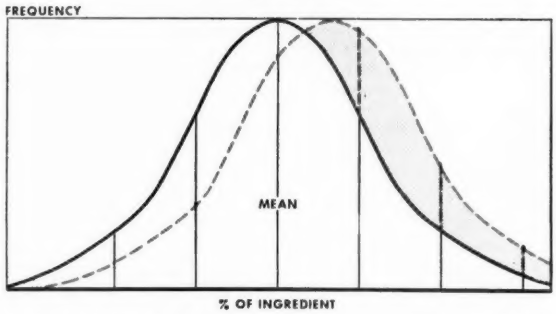


Fig. 6. The analysis of the distribution of current sample data is made in relation to last month's means and standard deviations. From such a comparison, significant trends can be recognized

tighter control of ash and sulphur variability when measured around current means than of moisture. From figures such as the coefficient of variation, operating management can set additional standards of operating performance. For example, operating management may determine that the washer can be operated within a five percent limitation for the coefficient of variation for moisture. Any values for this coefficient that are over five percent would then be considered substandard performance of washer operation in this area. A decision as to what the standards shall be for the coefficient of variation is dependent upon the compilation of historical data and an analysis of washer operating potentialities.

In summary, through statistical analyses U. S. Steel has tested, day to day, the cumulative week and the cumulative month analyses for continuity and consistency of the averages for ash, sulphur and moisture and also has tested the averages for the degree of variability experienced in current periods versus the degree of variability experienced in the previous month. As mentioned earlier, the statistical results are obtained with considerable speed through the use of the 650 computer. Thus, they are made available to metallurgical, and the various blast furnace, coke oven and coal operators so that timely remedial actions can be taken if significant differences are apparent. The company's collective aim is to supply the steel mills with coals that consistently meet optimum price-quality considerations. The program outlined is a step taken by the Metallurgical Department and the Coal Division of United States Steel toward the realization of this aim.

DIFFERENT MEANS - SAME STANDARD DEVIATIONS

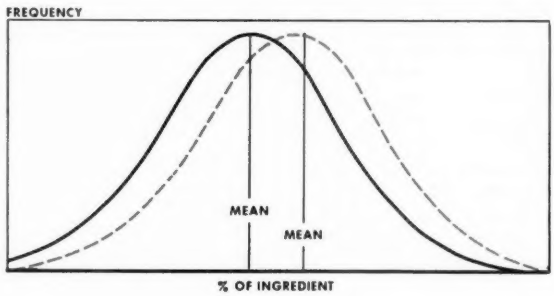


Fig. 7. The shape of the two curves indicates identical standard deviations, while the mean values are significantly different. If management used standard deviation only, it would know nothing about the significance of a change in mean values from month to month. The converse is also true as shown in figure 8

SAME MEANS - DIFFERENT STANDARD DEVIATIONS

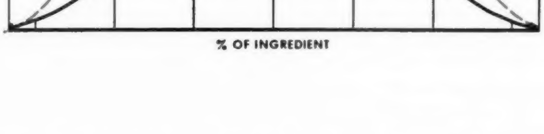


Fig. 8. The shape of the two curves indicates identical mean values, while the variability in the one case is normal and in the other is quite biased

Other Computer Applications

U. S. Steel's activities with the 650 computer have also extended into other fields. From time to time, economic worth evaluations are required of coals of various facilities and different prices. In addition to price, a complete economic evaluation of the coals under study must comprehend

the effect of ash, sulphur, volatile matter, natural moisture, and fixed moisture on coke oven operations, the quality of the resultant coke as it will affect blast furnace burdening requirements, and the economic effect of the analyses on coal chemical production and coke oven gas balance.

The calculations must also cover conditions in blast furnace operations involving constant slag volume, floating slag volume, and slag sulphur critical considerations. The completed calculations are FOB receiving works and indicate the relative economic worths of the various coals in relation to a base coal. In other words, the calculations tell management what the consuming plant can afford to pay for the various coals in relation to the base coal. When this information is compared with the price of the various coals FOB the receiving works, the cost-quality relationship of the coals is firmly established.

The program is applicable to all U. S. Steel's Central Operations coke oven and blast furnace operations. The present program can evaluate coals at any location for constant slag volume after request data is put on cards in the following time:

Read program and basic data
1 minute 40 seconds
For each coal
0 minutes 14 seconds

By conventional means this job would require approximately four hours for seven coals.

Fig. 9. Formula for the "t" test

$$t = \frac{\text{Error in Mean}}{\text{Standard Error of Mean}}$$

$$t = \frac{\bar{x} - \bar{x}'}{\sigma\sqrt{\frac{1}{n} + \frac{1}{n'}}}$$

Fig. 10. Formula for variance, which is the square of the standard deviation

$$s^2 = \frac{\Sigma (x - \bar{x})^2}{n - 1}$$

By changing one card, floating slag can be done in the same machine time as above. Manually, another four hours would be required.

A facility deck is maintained containing current basic and dollar standards for all appropriate coke plants and blast furnace installations. The user specifies the location in which the evaluation is to be made and through control numbers, the type of calculation desired. One base coal and nine comparisons can be incorporated and answers for any of the conditions or combinations of conditions referred to previously can be secured by the use of the single card control.

In addition to assuring rapid comparisons of coals in a specific location, that is, coke works and blast furnace, and rapid comparison of the same coals in any other location, there are certain by-products of the program:

1. **A comparison of the effects of standard versus actual coal quality at standard cost.**
2. **A comparison of the effects of standard versus actual coal quality at standard and actual coal cost.**
3. **A comparison of the effects of proposed changes in quality.**

This program is being used with success and has relieved the Industrial Engineering and Accounting organizations of a significant workload which was the result of performing the same calculations by conventional means.

The Timesaving Washability Program

In the interest of relieving laboratory personnel of the time-consuming operations of calculating cumulative ash, sulphur, volatile matter, fixed carbon, organic sulphur and other constituents by size fractions and various specific gravity considerations, a program has been developed for the 650 computer to precisely duplicate the calculations formerly made by conventional means. The program will calculate cumulative figures for the sink material as well as for the float material. It is broad enough to combine multiple sample data for ten specific gravity entries and six size separations.

Continuous Miner Program Flexible

A rather unique application of the 650 computer has been in the development of production and equipment hours standards for continuous mining machines. Space does not permit a complete explanation of this development but the program is a most successful one and is designed in such a manner as to be applicable to a wide range of seam conditions so that within reason, the program can be applied to various mine locations. It is not confined to the district for which it was initially developed.

A program has also been developed to calculate annual district operating plan balances resulting from normal annual clean coal requirements of the various coke works. Input data to the program consists of individual mine raw coal daily production and the standard ash content of each of the individual mine coals. After introduction of the input data, the program calculates mine participation in percent; individual mine and district raw coal productivity on a monthly and yearly basis; individual mine yields of washed coal from raw coal as well as the district yield; and also for individual mines and district totals, the clean coal tons per day, month and year. The program also calculates the number of days of operation required of the mines and the washer comprehending district capacity and coke plant requirements. Heat drier fuel requirements are also calculated within the program. This program as currently used performs in approximately three minutes calculations that require eight hours by an experienced industrial engineer using conventional means. This is the first step in assigning lengthy operating plan balances and standard cost calculations to an electronic computer.

Fig. 11. The "F" test in effect measures the degree of conformity of the current standard deviation results with the standard deviation results of the previous month

$$F = \frac{(\text{Current Standard Deviation})^2}{(\text{Standard Standard Deviation})^2}$$

$$F = \frac{s^2}{\sigma^2}$$

Fig. 12. The coefficient of variation is the percentage that the standard deviation is of the accepted standard mean value for ash, sulphur and moisture. This coefficient is indicative of the tolerances within which washer practices are operating

$$\text{Coefficient of Variation} = \frac{\text{Standard Deviation}}{\text{Mean}} = \frac{s}{\bar{x}}$$

Rock bolting practices at Homestake

By C. N. KRAVIG
Mine Superintendent
Homestake Mining Co.

The author discusses the application of rock bolts in metamorphic and sedimentary rocks and describes a new cost saving method developed for installing cemented bolts

In the Hauber uranium mine, the expansion shell type of bolt is used almost exclusively; however, the problems of anchorage and slacking ground have limited its application

OPERATIONS of Homestake Mining Co. include the Homestake mine at Lead, S. D., and the Hauber mine in northeast Wyoming. The Hauber mine is operated from Lead. Rock bolting is only one of several methods of ground support used at these mines. There are some conditions where steel sets are better, other conditions where timber is needed, and still others where concrete is required.

At the Homestake mine the rock formations are hard, pre-Cambrian metamorphic rocks consisting of cummingtonite schist, biotite schist and quartzite. A small amount of tertiary rhyolite occurs in the form of a dike zone. All these formations have numerous "slips" or fractures. Any heavy ground consists of rock breaking off or loosening up along the fractures.

At the Hauber mine, as well as in the uranium mines in Utah and New Mexico, the formations are flat-lying sediments consisting chiefly of sandstone and shale. Heavy ground in these mines is generally caused by slabs of sandstone or shale breaking off along sedimentary partings or fractures.

No Regular Pattern of Bolting

The main purpose of rock bolting is to prevent loose or heavy ground by bolting weak or fractured formations before they begin to fail. The bolting knits the formation into a solid unit or beam across any mine opening. Flat backs may be strong and sound when first opened up, but with air slacking, especially in the shale formations, much loose or drummy ground shows up in a few weeks unless rock bolting has been done. If rock bolting is deferred until the back becomes loose or drummy it often is too late to safely use this method of support, and then the loose back may have to be taken down or timbered.

In the Lead operations all "slippy" or fractured ground is bolted both in development headings and in stopes. Generally speaking, no regular pattern of bolting is used; the bolts are placed as marked by the shift boss or foreman. In highly fractured ground, however, a certain number of bolts may be specified for each round of advance in a development heading; this is particularly true of the lower levels where rock pressure tends to loosen up the ground if this bolting is not done.

In the stopes, rock bolts are installed as marked by the shift boss in

an effort to prevent loose or heavy ground. When mining around barren or low-grade rock, the back may become heavy and loose to the point of being "drummy," or there may even be cases of rock falls. In such cases stoping may be stopped, and the entire area may be bolted again by starting in a solid area and working toward the loose portion of the stope. Normally a standard washer is the only head plate used in connection with the bolting, but as the ground becomes more highly fractured, steel plates, strips or wire mesh are bolted to the rock. In extreme cases, wire mesh is bolted in place and then gunited.

Wedge Type Bolt Provides Best Anchorage

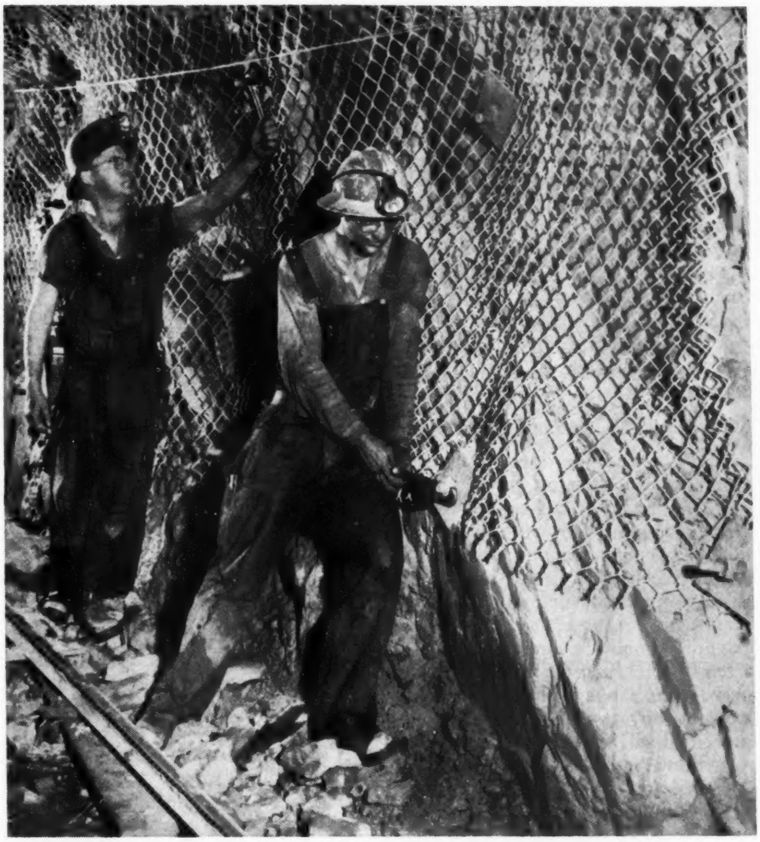
The wedge type rock bolt is used almost exclusively at Homestake, but a few expansion shell type bolts are also used, especially in the development drifts on the lower levels. In fractured ground on the deep levels, the rock quite often loosens up around the head plate within a few weeks after being installed. By using expansion shell bolts they can be removed and the drift may then be rebolted with considerable assurance of permanence.

In the hard rock formations in Lead, the wedge type gives a better anchorage and permits a larger rod in the $1\frac{3}{8}$ in. drill hole. Since the rock is hard, and drilling is slow, there is no problem in drilling the hole to a prescribed depth for this type bolt. In most cases the bolts are installed for permanence so there is little need for a bolt that can be removed. Bolts five ft and eight ft long are used in the development headings; and bolts five ft, eight ft, and ten ft long are used in stopes.

Hydraulic pull tests on the wedge type rock bolt at Homestake show that they support from six to nine tons. Tests on the expansion shell type invariably indicated a lower yield point.

Rock Formation Dictates Bolt Type

Another type of rock bolting that has been tried out is the "Perfo" system. In this method of bolting, two halves of a perforated tube are filled with a rich mortar of sand and cement and are then wired together and inserted into the drill hole. A reinforcing rod threaded on one end is then driven into the tube filled with mortar; the mortar is extruded through the perforations and fills the space between the perforated shell and the rock. When the mortar sets, the bolt is anchored throughout the entire length of the drill hole.



A standard washer is normally the only head plate used in connection with the bolting, but as the ground becomes more highly fractured, steel plates, strips or wire mesh are bolted to the rock

The Perfo bolt gives excellent support in heavy ground and especially in formations where good anchorage is not possible with the wedge or expansion shell types. Pull tests show that the elastic limit of the reinforcing rod is reached without any signs of failure in the cement bond. The steel rod has a yield point of 65,000 psi, so a $\frac{7}{8}$-in. re-bar supports a load of $19\frac{1}{2}$ tons before breaking, or a safe working load of six tons.

The perforated shell is used merely as a technique to introduce the correct amount of mortar into the drill hole. This principle of bolting is identical to that of "pinning"—a rock bolting practice used by Homestake over thirty years ago, and which had been successfully used many years prior to that time. This "pinning" type of bolting was used mainly on the hanging wall of shrinkage stopes. A rich mortar of sand and cement was pushed into a drill hole by means of a loading stick and then a $1\frac{1}{4}$-in. lug steel was driven into the hole; the mortar would flow around the rod and when set would form a bond between the steel pin and the sides of the drill hole throughout the entire depth of the hole. Some hydraulic pull tests on these pins showed that the elastic limit of the steel was reached without any failure of the cement.

New Method for Installing Cemented Bolts Developed

Homestake has developed a new method of introducing the mortar into the drill hole without a perforated shell. A thin-walled cylinder of a diameter that will easily go into the drill hole is filled with mortar and inserted into the hole; a piston or plunger is then pushed part way into this cylinder. The plunger holds the mortar against the bottom of the drill hole while the cylinder is removed, thus leaving the hole nearly full of mortar. A reinforcing rod is then driven into the mortar until it reaches the bottom of the hole.

The mortar fills the space around the rod with any excess being extruded out of the hole. When the

mortar sets, a washer and nut are screwed onto the bolt and tightened. Quick-setting cement may be used to hurry the process. This system saves the cost of the perforated shell and the resulting bond is very effective, as proven by hydraulic pull tests.

In heavy ground where the wedge type or expansion shell type bolts do not give sufficient anchorage, cemented bolts in conjunction with steel plates, provide very good support. Such bolting is more expensive both in labor and material; but where it can be substituted for timbering, it still is an economical type of rock support.

Temporary Support in Large Stopes

In some of the large stopes at Homestake widths up to 100 ft or more and lengths up to 400 ft are not uncommon, and rock bolts cannot be depended upon entirely to support such large areas where there is heavy ground. The natural arching of the rock in case of caving would extend beyond the anchored end of a ten-ft bolt. In order to bolt a back over such a span, the bolts would have to be long enough to be anchored above the natural arching in case of caving and enough bolts of the necessary length would have to be installed to hold the entire weight to the point of natural arching. This would require bolts in the neighborhood of 50 ft in length, which is too long to handle conveniently and would be impractical since rock bolting in stoping operations is only temporary; that is, until the next cut is mined. This does not mean that rock bolting is not used in the large stopes, but it does mean that the bolting is used only with the idea of supporting individual pieces of drummy or heavy ground and not the entire back. Bolting of large spans, however, does tend to tie the rock into one unit so that it acts as a beam and tends to prevent caving to an arch.

In the Hauber mine, as well as in the uranium mines in Utah and New Mexico, the expansion shell type of bolt is used almost exclusively, but the problem of anchorage and slacking ground has limited its application. In soft sandstone beds the wedge type bolt has proved ineffective because the wedge is driven into the sandstone rather than into the slot of the bolt, and no anchorage is achieved.

In some cases the expansion shell type of rock bolt may give fair anchorage in sandstone at the time it is installed, but if some water trickles out of the sand near the expansion shell there is a tendency for the sand to crumble away from it and the anchorage is lost. A check with a torque wrench some time after installation will test the anchorage. If the anchorage is lost, the miners have been working with a false sense of security.

Expansion Shells Installed in Plastic Cement

Installing expansion shell rock bolts in combination with a tube of plastic cement ahead of the expansion shell has been tried. As the bolt is pushed against the bottom of the hole, the tube of plastic cement is supposed to break and flow around the expansion shell. When the bolt has been tightened and the shell has expanded, the plastic is supposed to harden and prevent any washing away of the sand or mud thereby preserving the anchor. However, upon testing the bolts installed with the plastic cement, the anchorage was no better than with the standard expansion shell without plastic cement. There is some question as to whether the plastic hardening in the threads prevents proper testing with a torque wrench.

Certain weak shale formations in the uranium mines tend to cave quickly. In this type of rock neither the wedge type nor the expansion shell type bolt gives satisfactory results because a good anchorage is not always possible. In addition, air slacking loosens the shale around the head washer and as crumbling continues, the bolt is left hanging with no supporting value. If satisfactory anchorage is attained, air slacking can be controlled partially by steel strips, steel plates or wire mesh to prevent crumbling. In this type of ground, where the desired anchor is not achieved with the expansion shell type bolt, the only satisfactory type of bolting is the cemented pin or "Perfo" bolt in conjunction with steel plates or strips.

Used 43,000 Rock Bolts in One Year

Rock bolting experience at Homestake has demonstrated that much heavy ground which formerly was timbered can be supported by rock bolts. During 1958 Homestake used over 43,000 rock bolts. Nearly all of the development headings in loose or broken-up ground can be supported with rock bolts in conjunction with steel sheets, strips or wire mesh. The rock bolts are five, eight and ten ft in length which permits anchorage above any natural arching tendency. In the large stopes, however, only individual drummy boulders or "slippy" ground is bolted, but such bolting has permitted more open cut-and-fill stoping with a corresponding decrease in square set mining. In the uranium mines bolting in certain weak shale formations has had questionable value, but in firm sandstone has proven to be an effective type of support.

Bolts are placed as marked by the shift boss or foreman. In highly fractured ground, a certain number of bolts may be specified for each round of advance in a development heading

Equipment Needs and Trends For Mining in Seams Over 48 Inches Thick

Has the development of equipment capability passed the point of diminishing returns in cost reducing ability?

By E. H. GREENWALD
Partner
Eavenson, Auchmuty & Greenwald

THE word "need" is defined as "to be necessary"; the word "trend" as "to turn in a specified direction or course." A specific equipment need should and can be accurately defined by the functional requirement to be met; i.e., what the machine is to do exactly, including its productive capability and reliability. Obviously, the trend should be in the direction of meeting the need as closely as possible, in so far as design limitations and the use of available materials, etc., will allow.

The subject of this article is a very significant one. The "need" and "trend" in face mining and intermediate haulage equipment is the principal factor controlling the cost of production. It is not difficult to illustrate that the primary influence governing production costs, and in turn sales realization, is largely vested in those operations producing coal from seams 48 in. and thicker and will probably continue to be so within the foreseeable future. There just isn't any easy way of repealing the natural law to wit: "all things being equal, the cost of mining coal will vary inversely as the height of the seam being worked."

In spite of opinion to the contrary, the percentage of total production from seams 48 in. and thicker has not changed materially over the past 15 years and not significantly over the past 40 years. The following tabulation from U. S. Bureau of Mines statistical studies illustrates this.

Percent of Production from Seams

Year	Less Than 48"	48" to 72"	72" to 96"	Over 96"
1920	25%	45%	25%	5%
1945	31%	37%	23%	9%
1950	35%	35%	22%	8%
1955	34%	40%	20%	6%

The author does not expect to see any material percentage increase in production from seams less than 48 in. thick for many years—because of the ever tightening competitive situation in the fuel energy markets coupled with the abundance and favorable locaton of reserves in seams over 48 in. thick.

Decade of Evolution

In the last ten years the coal industry has established a tremendous record of increased productivity and cost reduction, all the result of a rapid evolution in mining equipment and management techniques.

The operator has contributed to this evolution by gradually but surely increasing machine output to a point more closely approaching a machine's capability. Ten years ago the workings of the second law of C. Northcote Parkinson, a noted British humorist, was very much in evidence at many mines. This law states that "work expands so as to fill the time available for its completion." Productivity of mining units were often geared to the longest cycle time or "bottleneck" in the total mining operation without any thought to balanced crews, improving work methods, etc. In the interim many companies have found that this law is less likely to be in effect if they undertake a good cost control program, along with the proper application of industrial engineering techniques.

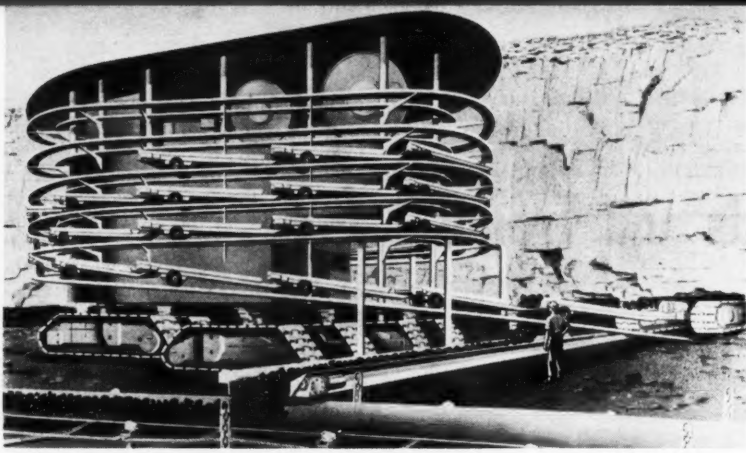
During this decade, the manufacturer has made available machines with ever increasing capabilities both as to productive capacity and versatility. In turn, the industry has been able to return to the manufacturer a profit level comparable to the best in the heavy equipment field. A substantial part of this profit has unfortunately stemmed from the sale of replacement parts. From the industry viewpoint, the purchase of replacement parts is a negative undertaking.

The Past, a Guide to the Future

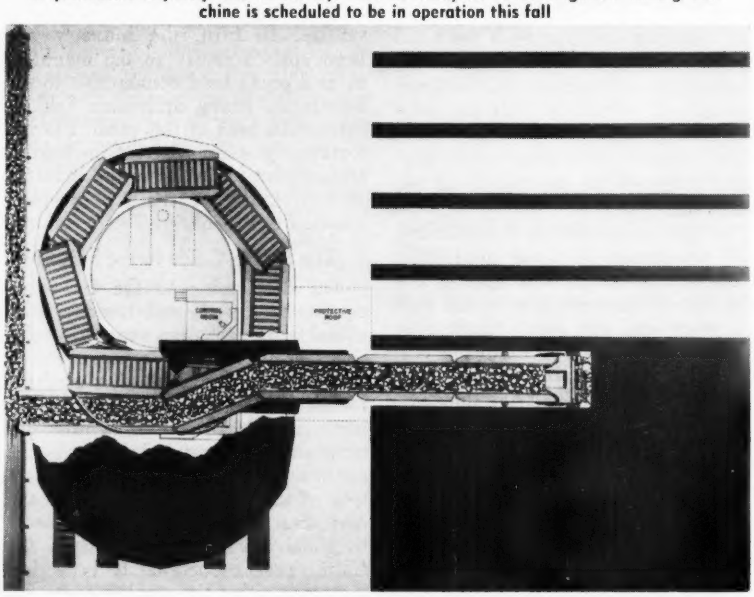
The best guide to the future of equipment "needs and trends" is to examine the effect ten years of evolution has had on the components of the cost of production for machine loaded coal. This will illustrate the areas in which cost reduction has been most effective and point out the resulting change in the relative position of the major components in the cost structure. It will further serve to show the most likely areas for future cost reduction. It is within these areas that the emphasis on continuing equipment evolution should take place.

Selected for this ten-year comparison is the record of a group of mines in a specific field who report cost in detail to an association. This particular field is noted for its over-all mining efficiency in a multitude of seams and has seam conditions varying from the worst to the best. Production is principally from seams over 48 in. and varying in thickness to more than ten ft. The figures cover machine loaded coal only in some new but mostly older mines. In most of these mines, face mining equipment has been periodically upgraded to higher capacity units as they became proven and available. Columns 1, 2 and 3 of table 1 present the details of this comparison.

Columns 1 and 2 of table 1 compare cost based on 1959 dollars versus 1949 dollars without allowance for inflation. Since 1949 the value of the dollar has decreased about 17.5



Manufacturers have made available machines with ever increasing capabilities both as to productive capacity and versatility. This remotely-controlled highwall mining machine is scheduled to be in operation this fall



percent. The 1949 cost in equivalent 1959 dollars would be $5.43 and costs have therefore actually been reduced $0.85 per ton or about 16 percent in this particular field over the ten-year period.

Table 1 shows, significantly, that within the major subdivisions in which individual management was able to exercise its prerogatives, costs have been reduced—specifically, direct labor cost (minus 22 percent), mine supervision and overhead (minus eight percent), and general administrative expense (minus eight percent).

Effect of Past Evolution on Labor Distribution and Costs

In making these cost reductions, it is obvious that the major effort has taken place in reducing the amount of labor employed at the working face with the reductions in the other categories principally the result of a cause-effect relationship. The reduction in productive labor costs has resulted from the increased productivity per man-shift at the face through better management and use of higher capacity equipment. As a result of this, output per unit shift has increased greatly and in turn the number of units needed to produce a given mine tonnage have been reduced substantially. This has reduced required productive mine area with associated reductions then occurring in service labor costs, supervisory and overhead expenses. The order in which these have occurred and their identity as to which is cause and which is effect is often misunderstood.

The cause-effect ratio between reductions in productive labor costs and service labor costs appears to be on the order of three to one for this field (a reduction of 32 percent in face labor costs has resulted in a reduction of ten percent in service labor costs). The similar ratio for associated reductions in mine overhead expense has been about four to one (32 percent vs. 8 percent).

The results of this cause-effect relationship has changed the relation between productive and service labor costs. In 1949, 57 percent of total direct labor cost was for productive labor at the face with 43 percent for service labor (from the loading point to the railroad car). At the end of 1959 the split was about 50 percent to 50 percent. As further proof of the trend in this relationship, at several recently constructed, ultra modern, high capacity mines in another field the ratio is reported to be 45 percent productive versus 55 percent service.

As table 1 shows, all of this has resulted in a substantial reduction in the percentage of total production cost represented by direct labor cost. At the end of 1959 direct labor cost equaled about 39 percent of total cost, versus 51 percent in 1949. This in spite of an 89 percent increase in base wage rates for the period. If this evolution at the face had not taken place, in this particular field direct labor costs would now be $4.33 per ton for machine loaded coal. The effective reduction has therefore been $2.55 per ton, equal to 111 percent of the 1949 figure.

Trends in Equipment Reliability

Figures from table 1 show that higher equipment capacity or capability has produced important results. Unfortunately they do not point out the importance of or the trend in equipment reliability. This can be defined as the average percentage of total available work time that the machine or unit can be expected to operate free of maintenance trouble. The fact that total production is a function of capability plus reliability is very well understood by those operators obtaining a high percentage of available equipment capacity.

The development of effective preventive maintenance and scheduled periodic rebuilding programs to obtain maximum operating time are the result of this recognized need for equipment reliability. Therefore, the cost of maintenance labor and supplies can serve as the criterion for reliability and the relation of these to the other cost components is of major importance in considering equipment "needs and trends."

Unfortunately the details on maintenance labor and supply costs are not available for the group of mines represented in table 1. However, from cost figures of several mines in this field it appears that the 1949 maintenance labor costs for mining

and face haulage equipment was about eight percent of the total direct labor cost. By the end of 1959 this percentage had increased to about 14 percent of the total. In the face of a 22 percent decrease in total labor costs, per ton maintenance labor costs increased about 36 percent in this ten year period. However, after factoring the 89 percent increase in base wage rates, there actually has been an effective reduction in the use of maintenance labor of 60 percent. This occurred at about one-half the rate of the reduction in total labor costs. Part of this reduction has resulted from the practice of having components and entire units repaired or rebuilt in job shops rather than at the mine. In so doing, the entire cost of an outside repair usually is accounted for in mine supply cost and in so doing a distortion occurs in the actual relation between labor and supply costs.

In making cost reductions, the major effort has been to reduce the amount of labor employed at the working face

The past decade has witnessed an increase of 56 percent in total mine supply cost. The cost of maintenance supplies for mining and face haulage equipment, including those used in major overhauls and rebuilding, was about 20 percent of total supply cost ten years ago, at these several mines. At present, this item makes up about 30 percent of the total. While total supply cost was increasing 56 percent in ten years, maintenance supplies, a major factor in total supply cost, increased 134 percent.

The effective increase is actually 117 percent if allowance is made for inflation. This increase versus the effective 60 percent decrease in maintenance labor indicates that the average item of maintenance supplies is now about three times as costly as ten years ago. Part of this is probably the result of accounting distortion because of the increased amount of job shop repair work being done, with most of it due to increased complexity of equipment and the use of more expensive materials by the manufacturer.

A Look at the Future

If the experience of the past ten years is repeated in the next ten, will the results be satisfactory? If not, then perhaps the present trend in equipment evolution will have to be altered.

As an insight into this, column 4 of table 1 presents the projected 1969 costs on the basis of applying the same percentage change in the various cost components that have occurred in the 1949–59 period. An exception is welfare, vacation and administrative expenses which have been projected without change.

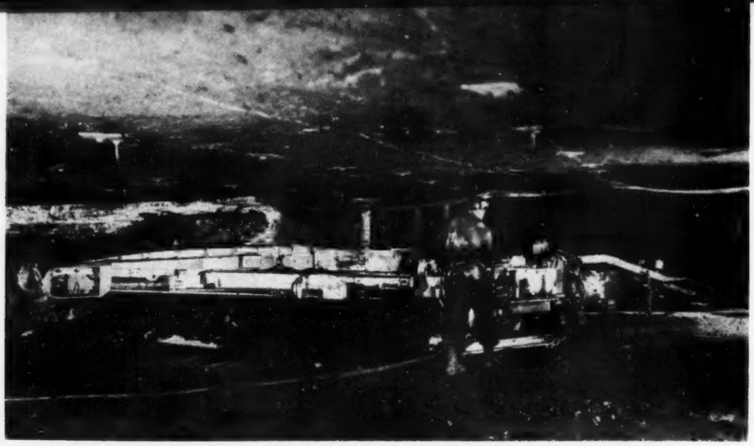
According to column 4, total direct labor charges will have then been reduced to 27 percent of total cost of production and the ratio of productive to service labor will be about 44 percent to 56 percent. The cost of supplies will then have exceeded the cost of labor, being about 33 percent of total cost which in turn will have increased about six percent over 1959.

A 270 percent increase in per man-shift productivity at the face will be required in this field to meet the labor cost in column 4, assuming base wage rates are again increased 89 per cent in the next decade. The 1959 cost indicates an average output of about 29 tons of clean coal per crew member. This will have to be in excess of 80 tons per man-shift in 1969. If this occurs, output per unit shift will have increased from an average of about 300 tons of clean coal to in excess of 650 tons, with a probable decrease in crew size of 20 to 25 percent.

The average productivity figures called for in 1969 are not far from those being attained today in this field from certain mining units using the latest high capacity equipment. It therefore appears reasonable to assume that another decade of equipment evolution similar to the last will witness the average employment of

Table 1. Comparison of the Cost of Production for Machine Loaded Coal from Field "A"— Comparing the Year 1949 with the Last Half of 1959

Item	(1) 1949 Cost per ton	(1) 1949 % of total cost	(2) Last half 1959 Cost per ton	(2) Last half 1959 % of total cost	(3) Percent increase or decrease	(4) Projected 1969 Cost per ton	(4) Projected 1969 % of total cost	(5) Possible 1969 Cost per ton	(5) Possible 1969 % of total cost
Productive labor	$1.30	29.0	$0.89	19.4	−32	$0.61	12.6	$0.21	5.3
Service labor	0.99	22.1	0.89	19.4	−10	0.79	16.3	0.66	16.7
Total direct U.M.W.A. labor	$2.29	51.1	$1.78	38.8	−22	$1.40	28.9	$0.87	22.0
Mine supplies	0.66	14.8	1.03	22.6	+56	1.61	33.2	1.20	30.3
Power	0.12	2.7	0.13	2.8	+ 8	0.14	2.9	0.14	3.5
Mine supervision, clerical and misc. Mine overhead expense	0.48	10.7	0.44	9.6	− 8	0.40	8.2	0.36	9.1
U.M.W.A. welfare and vacation pay	0.28	6.2	0.47	10.3	+68	0.47	9.7	0.47	11.9
Total mine cost	$3.83	85.5	$3.85	84.1	+ 0.5%	$4.02	82.9	$3.04	76.8
All taxes, insurance, compensation, dues and assessments	0.28	6.2	0.34	7.4	+21	0.41	8.4	0.41	10.3
Administrative expenses	0.12	2.7	0.11	2.4	− 8	0.11	2.3	0.11	2.8
Depreciation	0.25	5.6	0.28	6.1	+12	0.31	6.4	0.40	10.1
Total cost of production (exclusive of depletion and tonnage royalties)	$4.48	100.0%	$4.58	100.0%	+ 2%	$4.85	100.0%	$3.96	100.0%



Total production is a function of equipment capability plus reliability

mining units with this required capacity.

As to equipment reliability, the figures of the past decade indicate that the evolution in reliability has not kept pace with increased capability. To achieve the projected production per man and per unit the necessity of obtaining maximum equipment availability time will be even more critical than it is at present. Unless there is a substantial reduction in the maintenance requirements of new equipment, the methods now used to assure maximum equipment operational time will have to be intensified and possible new approaches to the problem devised.

The past trend is projected into the future as another 36 percent increase in per ton maintenance labor cost to where this item will equal about 25 percent of total labor ten years from now. Unless efforts are made to the contrary in the design of new equipment, the next ten years could also see a major portion of the 134 percent increase in the per ton cost of maintenance supplies repeat itself. This item would then equal some 45 to 50 percent of the cost of all mine supplies and would actually be substantially higher than productive labor costs.

Future Performance and Costs

The assumption made in projecting the costs shown in column 4 is that the evolution of the past ten years has occurred at a constant rate. Actually the rate was rather slow from 1949 to 1952 and then accelerated sharply. The curve of annual increase in productivity strongly indicates that the projected costs for 1969 can be bettered substantially if equipment reliability is improved. This is most likely to occur if the competitive position of the industry is seriously threatened in any way.

In examining the capabilities of different pieces of equipment available today, it is obvious that some (especially continuous miners) are much advanced beyond what is required to produce the costs shown in column 4. A further substantial decrease in productive labor costs can take place by improving auxiliary units to the point of attaining balanced unit capability and improving reliability to where it matches capability.

It appears reasonable to assume that the needed evolution in capacity of auxiliaries (particularly face haulage systems) will take place in the next ten years. For this reason column 5 of table 1 has been presented to show the cost structure that appears to be possible, assuming the required equipment is made available and the companies are capable of supplying the necessary capital dollars for purchases. At this point total direct labor costs will be 21 percent of the total cost of production and the ratio between productive labor and service labor will then be 24 percent to 76 percent.

The cost figures shown in column 5 call for a mining unit capable of delivering an average of 1200 tons of clean coal per operating shift with a five man crew. Output per manshift would be 240 tons. Yearly output per operating unit would be at least 600,000 tons.

To meet the figures in column 5, equipment reliability will have to be improved substantially and in turn the per ton cost of maintenance reduced over what is projected in column 4. An effective reduction of 50 percent in maintenance labor below present levels is neded, without at the same time having any increase in the present per ton cost of maintenance supplies. The unit should probably be able to produce at least 2,500,000 tons before requiring a major overhaul. The over-all requirements for maintenance should be at least 55 percent less than what is needed for today's equipment.

The First Cost of Mining Equipment

In strip mining where large excavators are employed, the relative importance of the first cost of the machine is well understood in reference to its capability and reliability. Depreciable cost, the operating cost and the maintenance cost per unit of material moved are each given proper evaluation. Unfortunately in deep mining, there seems to have been little effort put forth in the direction of making this type of evaluation. As a rule of thumb, with large earth movers the purchaser can expect to spend from 2 to 2½ times the first cost of the machine in maintaining it over its depreciable life.

Ten years ago the latest unit of conventional off-track mining equipment for operation in a 60-in. coal seam had a first cost of approximately \$91,000. Such a unit possibly produced 100,000 tons a year. Over a ten-year depreciable life a total of 1,000,000 tons of production resulted in a depreciation cost per ton of approximately 9.1¢. Over the same ten-year period the operator of this equipment could expect to incur total maintenance and repair costs in excess of \$300,000. The ratio of first cost to maintenance and repair costs ten years ago was then on the order of 1 to 3.5.

Today, the first cost of the latest conventional mining unit to operate in this same seam height is approximately \$207,000. This unit may produce 200,000 tons per year and over a ten-year period, 2,000,000 tons at a depreciation cost of 10.4¢ per ton. After applying the 17.5 percent inflation factor, it seems obvious that although there has been an increase of 128 percent in the first cost of this type of mining equipment, along with the 100 percent increase in capability, the purchaser is now obtaining at least seven percent more capability for his equipment dollar than he did ten years ago.

Unfortunately, reliability, as measured by the cost of maintenance, has traveled the other direction. Over a ten-year depreciable life the owner of this type of mining equipment will probably incur maintenance expense in excess of \$1,100,000. Over the last ten years it appears that the ratio of first cost to maintenance cost has increased from 1 to 3.5 to 1 to 5.4.

If this trend is continued for another ten years at the same relative rate, the first cost of such a unit in 1970 will be \$472,000, and the owner will incur maintenance costs in excess

of $4,000,000 in producing 4,000,000 tons of coal, over its ten-year life—a ratio of 1 to 8.3, first cost versus maintenance cost. This is in line with the projected cost figures in column 4, table 1.

The cost figures given in column 5 could be met by a unit capable of producing 6,000,000 tons over a depreciable life of ten years. These costs also demand a reduction in maintenance requirements of at least 55 percent under what is needed for today's equipment. Even so, there would be available for maintenance of this unit, total funds in excess of $3,300,000 over its life. With this degree of quality built in a mining unit, the cost savings in maintenance vs. what the trend now indicates will happen, could be on the order of 60¢ per ton. Using the ratio of 1 to 2.5 now common with large excavating machines, the purchaser could afford to pay approximately $1,350,000 for the mining unit which in turn would be depreciated at the rate of 22.4¢ per ton, an increase of 12¢ per ton over present figures. The net savings, being the difference in the reduction in maintenance costs versus the increase in cost of depreciation, would be substantial.

Need for Improving Equipment Reliability

Although this study was intended to develop conclusive evidence as to specific equipment needs for seams 48 in. or thicker from the standpoint of capability, the results have instead focused attention on a matter of apparent greater significance. In the author's opinion it is now obvious that a substantial realignment in the present thinking of the equipment manufacturers and the purchasers as a group is necessary if the future economics of the cost of production of deep mined coal are to continue on a favorable basis.

The development of equipment capability has apparently passed the point of diminishing returns in cost reducing ability. At the same time, in the effort to achieve capability the relative importance of other cost factors such as depreciation and in particular maintenance expenses do not appear to be receiving the type of factual consideration given them in other industries. To the author it appears that the future in the mining equipment field belongs to the manufacturer who can achieve the proper balance between capability and reliability in the products he develops and sells.

Roof Bolting*

SIX roof bolters lost their lives as a result of roof falls during 1958. During that year, estimates indicate that 161,061,696 tons of coal were mined under bolted roof, which entailed the installation of 36,032,832 bolt units. Thirty-five percent of all bituminous underground mining was done under bolted roof.

You might say that six deaths don't seem like much. But all six of those deaths *could have been prevented!*

The immediate hazard to roof bolters is, of course, falls of roof and sides. This hazard can be greatly minimized if the roof bolters will follow this simple rule: do not advance beyond the last permanent support unless temporary support or equivalent protection is used!

Another prime hazard is the fine dry particles of dust encountered in drilling, especially when the drilling is done in high silica stratas. This hazard can be lessened by:

1. **Using sharp bits to reduce the amount of finely divided dust created.**
2. **Allaying the production of dust by using water on the drill bit.**
3. **Using efficient dry dust collectors.**
4. **Wearing effective respirators.**

Roof bolters are also exposed to other hazards, such as those encountered in transportation, handling materials, falls of person, etc. All of these can be greatly minimized by using common sense and by following company rules to the letter.

The roof bolter can contribute much to coal mine safety. His contribution is very important to himself and also to his fellow workers. He can set an example by:

1. **Following the agreed roof bolting plan.**
2. **Providing adequate temporary support before going beyond the last permanent support.**
3. **Seeing to it that each bolt is installed properly.**
4. **Seeing that dust-control devices are in good working order and are used during drill.**
5. **Keeping alert and conscious of the hazards peculiar to his job.**
6. **Remembering that it is the chance-taker who bets his life against long odds, only to find that the deck is stacked against him.**
7. **Being careful. He can possibly save a life, and the life he saves may be his own!**

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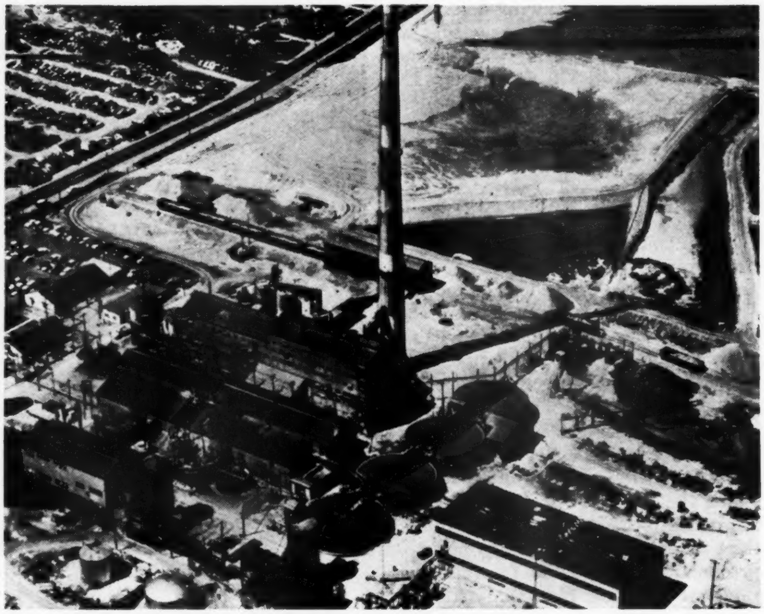
* *Prepared by the Advisory Committee 1960 National Campaign to Prevent Injuries From Roof Falls in Coal Mines.*



Salt Lake City mill of Vitro Chemical Co. exceeded its design capacity in 1959 by producing 1,495,000 lb of U_3O_8 as high grade concentrate. A growing amount of the output from such mills is ultimately finding its way into commercial uses, but this still represents a minute share of the total production

Nuclear Power and Fuel Requirements: OUTLOOK for Commercial Use of URANIUM

By NORMAN A. SPECTOR
President, Vitro International
and
Vice President,
Vitro Corp. of America

PREDICTION of nuclear power growth has been a most difficult task and it must be the great challenge that has appealed to many, for there is no shortage of such projections.

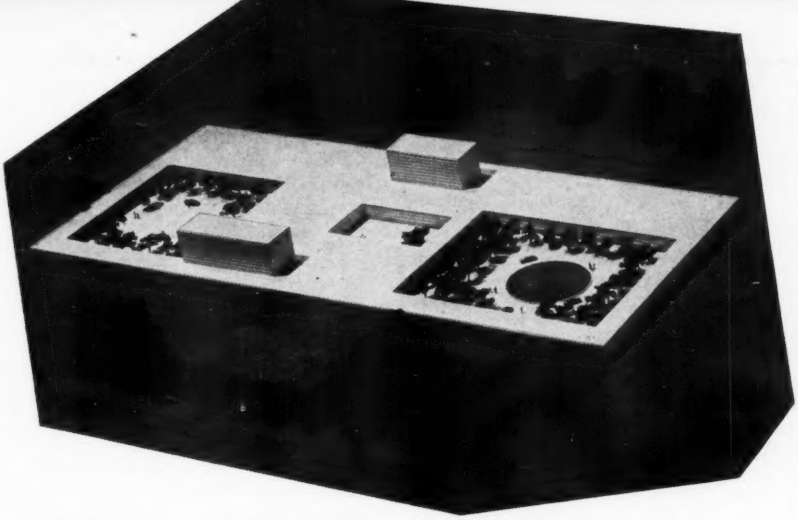
It has been estimated that we in the United States can logically expect to provide one-half of the requirements of Euratom during the period through 1968—say 4500 MWe (megawatts electrical)—and perhaps an additional 1000 MWe in other areas. This represents a requirement for initial inventory alone of approximately 25,000 tons of uranium or some 33,000 tons of concentrate. An estimate (Atomic Industrial Forum Survey) of foreign and nuclear power installed by 1969 is given below.

World Area	Cummulative Total, Megawatts electrical	
	Maximum	Minimum
United Kingdom	12,000	7,000
Euratom	8,700	4,800
Other Western Europe	1,700	800
Canada, Latin America	800	400
Asia, Pacific	1,000	500
	24,200	13,500

Assuming the uranium industry to be operating at an annual rate of 18,000 tons of concentrate and further that half of this production is required for military usage, it is apparent that this country could easily supply the fuel requirements for U. S. types sold abroad during the next eight years and still have about an equal amount (30,000 tons) for a domestic program or stockpiling.

U. S. Will Continue as Major Free World Source

It seems highly unlikely that a domestic program of this magnitude will come in to being during this period. However, we may find that concentrate and fuel sales are possible even where U. S. reactor types are not involved. In support of this view we need simply to realize that although it has been estimated that the U. S. should furnish some 25 percent of the total capacity installed in this period, our production of concentrate is about 40 percent of the Free World total. To put it another way, assuming almost any reasonable figure for United Kingdom military application; there does not appear to be nearly enough concentrate production outside the U. S. to supply the needs for this build-up overseas. Relative to this, an Organization for



Commercial use of uranium is spreading world-wide and into all areas of civilization —but slowly. One consumer-to-be is the Government of India, which will use uranium fission products in a modern, $4,000,000 radiological laboratory being built in Trombay. The facility was designed by Vitro International

European Economic Cooperation estimate of nuclear capacity installed overseas by 1975 is given below.

World Area	Cummulative MWe
United Kingdom	35,000
Euratom	40,000
Other Western Europe	10,000 – 25,000
All others	25,000 – 75,000
	110,000 – 175,000

Assuming that our domestic program becomes competitive in major areas during this period, then U. S. nuclear capacity by 1975 is estimated at 50,000 MWe for a Free World total of between 160,000 and 225,000 MWe.

Based on this growth it would seem necessary for Free World concentrate production to double in order to meet electricity requirements alone of 40,000 to 100,000 tons of uranium after 1970.

The above projections have been presented because they are authoritative surveys made by responsible organizations with the best information available at the time.

Because these figures deal with the future, they may yet turn out as good estimates. However, the progress of technology and related economic events in the past year or two have caused many forecasters to lower their sights. Estimates of installed nuclear generating capacity for the Free World have more recently ranged between 60,000 and 100,000 MWe by 1975.

Only time will show which, if any, of these projections are accurate. An examination of recent progress in technology and the current political-economic scene can guide our present outlook for nuclear power and the commercial use of uranium.

Aim of U. S. Nuclear Power Program

It would appear almost axiomatic that we here in the U. S., blessed with ample supplies of economic fossil fuels, must view nuclear energy as another form of fuel in our natural endowment of energy reserves. The basic aim of our program should logically be an orderly development of nuclear power for the production of electrical energy at a cost no greater than electrical kilowatts produced by burning coal or oil and at a time that does not endanger our conventional reserves.

Such a policy permits examination of alternative schemes and the development of optimum reactor types before major production investments are committed and fundamentally, this is our policy. If our program under this policy is attacked as too little and too late, or as lacking in leadership before the rest of the world, or lagging in the nuclear kilowatt race, we must keep our domestic perspective and recognize these as political factors on the American scene as well as propaganda factors on the international scene where the measure of technological skill has become a symbol of prestige, power and success.

The civilian power reactor development program of the Atomic Energy Commission has been sharpening its objectives and has recently stated them as follows: First of all, there are *two so-called short-term objectives;* (a) to reduce the cost of nuclear power to levels competitive with power from fossil fuels in high energy cost areas of this country within ten years, and (b) to assist friendly nations now having high energy costs to achieve competitive levels in about five years.

Three longer-range objectives are: (a) to support a continuing long-range program to further reduce the cost of nuclear power, (b) to maintain the U. S. position of leadership in the technology of nuclear power for civilian use, and (c) to develop breeder type reactors to make full use of the nuclear energy latent in both uranium and thorium.

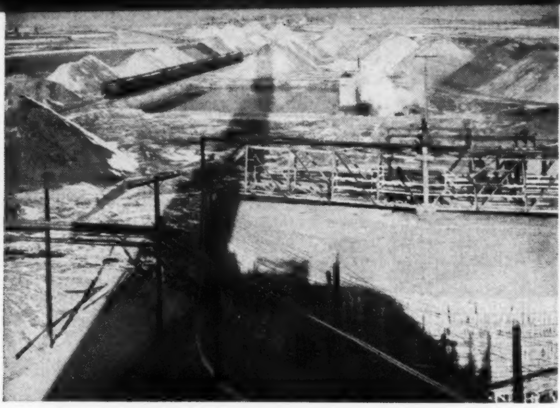
Reactor Designs Evaluated by AEC

Since these are not new objectives, but rather the original policy brought down to a more exact focus, let us turn to the recent AEC evaluation program on the current status of development and indicated economics of four major reactor types. Design studies were made on large pressurized water, boiling water, organic cooled and heavy water moderated reactors by AEC contractors who were each asked to determine the specific reactor concept variation and size for the most economic nuclear power plant that could be built, starting construction in July 1960. They were asked also to prepare a conceptual design in sufficient detail to estimate capital and operating costs, research and development requirements and operating and safety characteristics.

The AEC reports as follows on this evaluation program:

"We have reviewed the design studies very carefully and have attempted to normalize the many factors that enter into estimates of economics from such studies. We conclude that none of the specific designs submitted is likely to be competitive with conventional units of the same capacity in any area of the United States where units of the size proposed would be used. A cost differential of one mil or more per kilowatt hour is probable. We conclude further than there is no major difference in the cost of power to be expected among the boiling water, pressurized water, or organic reactors as designed—all having an estimated cost of power of perhaps eight to nine mils per kilowatt hour under the ground rules used. The estimated cost of power from the heavy water moderated reactor is at least one mil per kilowatt hour more than for the other three systems."

That we have not achieved low cost, competitive nuclear power that can be in production by 1964 is perhaps a disappointment to those who had higher hopes and lesser experience in the development of new in-



Stockpiled uranium ore provides feed material for uranium oxide production at Vitro Chemical Company's Salt Lake City plant

dustries. To those who are more mature in their judgment of new frontiers of science, and especially to all who have labored in the service of the peaceful atom, it is encouraging and gratifying to be so close.

Many important technical achievements are being made in our reactor development programs both government and in cooperation with industry.

However, with the economic "breakthrough" of large nuclear generating stations yet in the future, it is necessary for businessmen who must plan for the short-term as well as for long-term periods ahead to recognize our current position.

It would perhaps be today's reactor development status that would lead to an outlook for the minimum estimate of 2000 MWe reported by the AIF survey in 1958 for the period through 1968.

With continued achievement in our experimental programs and from operating experience to be gained from several large stations now being completed it is possible that the next three years will justify substantial increase in this minimum projection.

Foreign Incentives and Challanges

Our situation differs from that which prevails in most of the rest of the world. In 1956, for example, it was necessary for Britain to import 19 percent of its fuel requirements. Anticipated increases in coal production through large investment in modernizing mining will not exceed 15 percent and will fail to fill the gap.

The same situation exists in all the Euratom countries, which now import 25 percent of their energy requirements at a cost of some $2 billion a year. By 1965 these import requirements will increase to $4 billion a year and by 1975 to $6 billion a year.

Because of the relatively high cost of coal and oil in Europe, the present range of the cost of power from new plants using fossil fuels is from 50 to 100 percent higher than the U. S. range. Moreover, the Suez developments in the Middle East brought home the dangers of excessive dependence on oil from that area.

In view of the different and compelling need which faces foreign countries in the matter of energy resources and production, we can summarize the challenge of nuclear energy to meet this future as follows:

(1) Fossil fuel costs are high and may move higher. Achieving immediate cost parity in nuclear plants and conventional plants is less important than the necessity of meeting and maintaining the growth in electric power loads.

(2) Prospective foreign exchange savings, by reducing future imports of fossil fuels, may help moderate balance of payment problems of fuel-deficit nations.

(3) An assured supply of nuclear fuel at stable or decreasing prices is preferable to the uncertain terms and availability of oil, the primary means of meeting the growth in power demands in most of the Free World outside the U. S.

(4) Many nations, particularly the underdeveloped, are pursuing programs of rapid economic development while trying to reduce their dependence upon the older industrialized economies. Nuclear energy seems to promote this trend.

Promise and Problems

As a consequence of the potential situation abroad, it is not hard to see why so many have viewed the foreign market for nuclear power as developing earlier and somewhat faster than on the domestic scene. Indeed, these are the underlying factors which have produced the estimates of nuclear power growth previously presented and which indicate total foreign nuclear power installed by 1969 may be at least twice and possibly five to ten times the capacity constructed in this country in the same period.

This is the promise, but now that the first flush of enthusiasm has paled we can begin to see the shadows of problems.

First, there is in the writer's opinion a degree of reluctance, perhaps not originally anticipated, on the part of foreign clients to accept the current economics of nuclear power systems. They seem to have expected more than we are offering today. As a result while there is unquestionably a start on the road to nuclear power, instead of the fast start and a fast pace which presages record achievement, we have seen a beginning which is described as cautious, critical and questioning. As evidence of this situation we have the slow and difficult progress of the U. S.-Euratom program, despite the several assists and incentives which we had considered this agreement to provide.

Next there is the question as to whether the need for new power installations—however accurate the forecast for the longer term—may not have been overstated for the immediate future.

Availability of Fossil Fuels

There is the practical matter of coal costs as related to over-all internal economic impacts and this inevitably touches off a reaction in the political sectors which affect national policy and planning. Another factor is increasing unemployment of coal miners and more recently increasing unrest and actual revolt over this situation in Belgium and Germany.

Even though it can be argued that this type of displacement is always marked by such problems and must eventually be overcome by the ultimate advantages of a new concept; it is clear that such situations, given added fuel in some circumstances by political motivations, must slow rather than hasten the start of large nuclear programs.

At the same time there is the factor of new oil and new gas availability to Italy and France and accordingly to the Continent. The enhanced prospects which have resulted from recent Italian agreements in producing areas and from new discoveries in Sicily and the Sahara have received wide publicity. Again, even if such developments do not change the longer term projections for the growth of nuclear power, it is unreal to doubt that many will wish for the present to wait a bit and see.

Nuclear Power in Underdeveloped Nations

Finally, in order to look at a completely different face of the problem, consider the example of a nation at present underdeveloped and with low income but in the course of rapid industrialization.

India has reserves of hydroelectric

AMC Mining Show — Oct. 10-13

Final arrangements for the 1960 AMC Convention and Exposition are nearing completion—pointing up the fact that time is growing short for making plans to attend the year's most important meeting of metal miners and industrial minerals producers.

The program, now firmed up, will be featured in the September issue. It is a well-rounded program that promises to be of great interest and value to all mining men. Convention sessions will cover increasingly important matters pertaining to National policies affecting minerals and new ideas in operating practice and technology.

Requests for space at the exposition continue to be received, with some 200 leading manufacturers already planning displays of the latest in equipment and supplies. Operators will have plenty of time to consult manufacturers' technical representatives and an unequaled opportunity to inspect and compare a wide variety of products used in exploration, production and treatment of minerals.

The exposition, together with the convention sessions, will round out four full days of special activity designed to bring many new ideas to operating men—ideas that can mean real savings as well as more efficient and safer operations.

Convention visitors will be free to enjoy the night-time attractions of Las Vegas to the fullest since no official AMC evening functions will be held.

Activities for the ladies will include a luncheon and fashion show on Tuesday, and on the following day a reception at the beautiful home of Mr. and Mrs. Joseph W. Wells.

On Friday following the convention, two special trips are planned for the pleasure of convention-goers. One group will travel by bus to several nearby facilities, including the Apex kiln plant and one of the quarries of U. S. Lime Products Division of The Flintkote Co. At Henderson they will visit the chlorine and caustic soda plant of Stauffer Chemical Co., the magnesium section of the integrated titanium plant of Titanium Metals Corp. of America, and the chemical manufacturing facilities of American Potash & Chemical Corp. After a barbecue lunch at Blue Diamond, the group will tour the gypsum mining and manufacturing operations of Blue Diamond Co., Division of The Flintkote Co.

The second group, which will fly to Ely, will spend a day at the operations of Kennecott Copper Corporation's Nevada Mines Division, where they will inspect the mine at Ruth and the mill and reduction plant at McGill before returning to Las Vegas in the late afternoon.

Accommodations at Las Vegas' many fine hotels and motels are still available through the AMC Housing Bureau, Convention Center, Paradise Road, Las Vegas, Nevada.

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capacity of approximately 40,000 MWe and her known coal reserves of 40,000,000,000 tons are not large by world standards. For the long term, then, if India is to achieve her industrial goals and not be hampered by a power shortage she too must look to nuclear power. While the country's coal lies in the East and there is major electrical demand in the West, building railroads to move the coal would contribute to a strengthened transport system needed for other commodities.

Dr. Bhabba, who leads the Indian atomic energy program, has shown that in underdeveloped countries embarking on a long period of industrial expansion, even with transporting coal 700 miles, the total investment in thermal generating capacity was less than that required per kilowatt of nuclear power in distant areas. This was true even at an interest rate as low as 4½ percent.

The nuclear power plant being built at Indian Point, N. Y. by Consolidated Edison Co. is typical of installations which are making increased use of uranium fission products.

India has made a major start on a nuclear program and has planned a most ambitious nuclear power program for the years ahead. Presenting this example illustrates the ultimate existence of large nuclear markets, the influence of political and general economic factors which tend to delay the development of these markets and emphasize that factors other than the progress of reactor technology alone will contribute to the acceptance of nuclear power as competitive.

The Washing Cyclone

By J. P. MATONEY
Chief Engineer
Special Apparatus Division
Heyl & Patterson, Inc.

. . . An efficient tool for fine coal preparation

SOME years ago, a research and development division of the engineering department of Heyl and Patterson, Inc., was established. One of the functions of this division was to study fine coal cleaning and water clarification problems, it being this group's responsibility to develop methods and equipment to solve problems associated with the processing of fine coal.

It was soon developed that some improvement could be made in the methods used to clean fine coal; and that in the future, coal operators would be faced with cleaning more difficult coals at lower specific gravity than could be obtained by existing equipment in order to prepare the low ash-low sulphur coals required by more critical markets.

Heyl and Patterson's work on cyclone thickeners was being conducted at the same time as the investigation of cleaning devices and processes. In laboratory testing of the cyclones, it was noticed that the cleanest coal could be found in the coarsest size fractions in the overflow stream of the cyclone.

Operation Explained

There have been many attempts made to explain the mechanics of a washing cyclone. It is generally agreed that when dense medium is fed to a cyclone, gravity differentials are set up which vary from the air core to the cone wall and from the bottom of the vortex finder to the apex of the cone. Light elements in the feed float in towards the core; heavy elements in the feed stay against the cone wall or if caught in the central low gravity section of the cone, quickly sink away to the wall. The centrifugal effects within the rotating mass of medium water and feed solids, tend to multiply the specific gravity differences and account for the amazingly sharp partition curves which are observed.

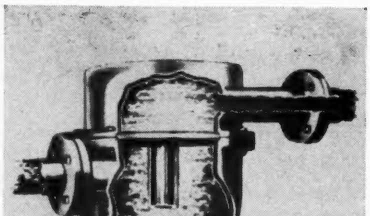

Fig. 1. Cutaway view of a washing cyclone

This picture, while undoubtedly valid, does not give a means of evaluating performance with differently constituted feeds, so the company has developed a somewhat different picture.

On figure 2 is plotted a typical cyclone thickener or classifier curve with water used as the carrying liquid. The curve is invariably "S" shaped. Various points on the curve are identified in the figure and have been explained by several authors. The physical characteristics of the solids and the physical characteristics of the liquid carrier affect the shape and slope of the recovery curve for any given cyclone.

Figure 3 shows a family of curves which illustrates how materials of

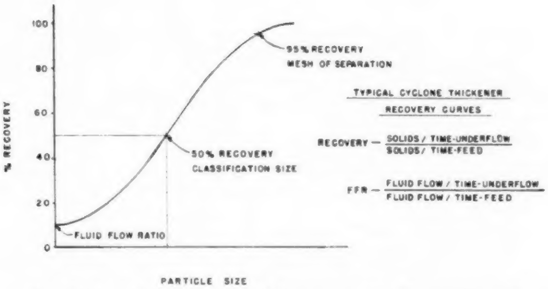

Fig. 2. A typical cyclone thickener or classifier curve with water used as the carrying liquid. The physical characteristics of the solids and of the liquid carrier affect the shape and slope of the recovery curve for any given cyclone

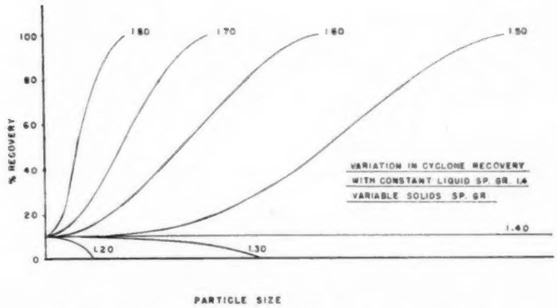

Fig. 3. The family of curves illustrates how materials of varying specific gravity are recovered by a cyclone

varying specific gravity are recovered by a cyclone. Since the liquid specific gravity is 1.40, the particles of 1.40 sp gr actually act as part of the liquid and split between underflow and overflow of the cyclone, according to the manner in which the feed volume splits, regardless of the particle size. Particles higher in specific gravity than the carrying liquid are recovered in the underflow of the cyclone at increasing rates as the difference in specific gravity increases and particle size increases. Particles lower in specific gravity are discharged through the overflow orifice of the cone at increasing rates as the specific gravity difference increases and particle size increases. All the curves, however, begin at the fluid flow ratio point for the finest particles of any gravity. The fluid flow ratio is defined as the rate of fluid flowing from the underflow to the rate of fluid flowing in the feed. Of course, this point is a limiting value for the recovery of the theoretical zero micron particle in the feed.

When these facts are checked against the requirements of an efficient specific gravity separator, it can be appreciated why a cyclone is an excellent fine coal washer. In a properly designed cyclone thickener, particles as small as 100 mesh are very easily collected with only traces of coarse material in the overflow. Because the requirement for a coal washer is that it collects refuse in one stream and coal in a second stream of particles generally larger than 28 mesh, the specific gravity separation can be made with nearly perfect accuracy.

Eight-In. Cyclone Part of Test Equipment

Some of the first tests conducted used an apparatus shown in figure 4. The cyclone was eight in. in diameter, and was fed by a vertical pump. The cyclone products were discharged to a vibrating screen which was partitioned to accept the refuse and clean coal products of the cyclone. Various combinations of feed, overflow, and underflow orifices were tested together with variations in coal feed sizes, media specific gravities, and feed pressures.

Washing Efficiency Decreases as Particles Become Finer

Among the first curves developed which are of primary interest is the family shown in figure 5. These show the performance of the eight-in. diam cyclone processing ¼-in. by 0 bituminous coal obtained from the Pittsburgh seam. During this test, in order to eliminate from considerations any effect of media size or concentration, a medium of calcium chloride in water, at a specific gravity of 1.30, was used. The average washing gravity obtained was 1.36. The following conclusions were reached by studying the curves:

1. **The slope of the separation curve decreases with particle size indicating, as in other cleaners, the washing efficiency decreases as the particles become finer.**
2. **The specific gravity of separation increases as the particles become finer.**
3. **Average ecart probable is about 0.02. Ecart probable for 18 by 28-mesh coal is 0.035.**

Subsequent runs with media such as fine magnetite and barytes mixed with water to various specific gravities were made. These tests showed sharp partitions. They also demonstrated that when a medium made up of finely ground materials of high specific gravity is used, there is an increase in washing gravity over medium gravity much greater than that shown by the true liquid. This increase in washing gravity is due to the concentration of the media solids by the centrifugal action of the cyclone itself.

Figure 6 shows the separation curves for ¼ in. by 28-mesh coal while using a medium of calcium chloride dissolved in water compared to the same coal in a medium of finely ground magnetite (Grade B, 95 percent—325 mesh). The curves show about the same slope, indicating equal washing efficiency, but with a 1.25 medium of magnetite a washing gravity of 1.35 was obtained and with a 1.30 gravity me-

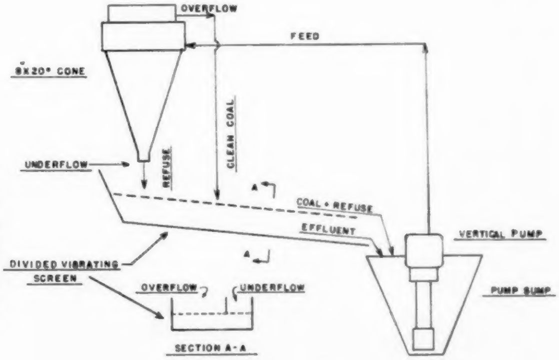

Fig. 4. Various combinations of feed, overflow, and underflow orifices were tested together with variations in coal feed sizes, media specific gravities, and feed pressures

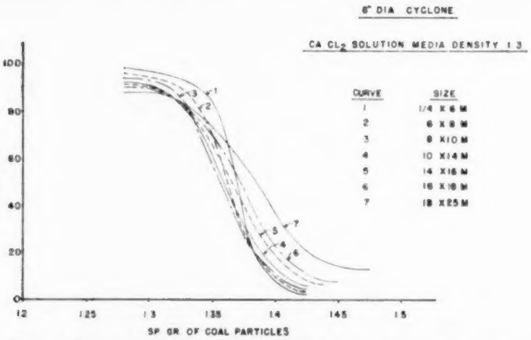

Fig. 5. Curves show the performance of a cyclone processing ¼-in. by 0 bituminous coal from the Pittsburgh seam. Note that the slope of the separation curve decreases with particle size indicating that the washing efficiency decreases as the particles become finer

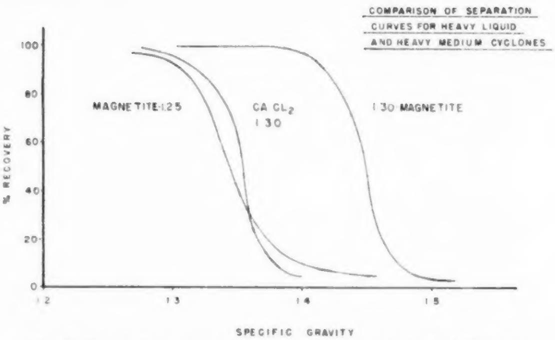

Fig. 6. Separation curves for ¼ in. by 28-mesh coal while using a medium of calcium chloride dissolved in water compared to the same coal in a medium of finely ground magnetite

dium a washing gravity of 1.45 was measured. The washing gravity with a 1.30 gravity solution of calcium chloride was 1.36, indicating an effective increase in washing gravity of 0.09 when a granular medium is used in place of a heavy liquid.

A second series of tests was then conducted in an attempt to evaluate the effects of feed pressure, media coal relationships, and variations in washing gravity with changes in orifice sizes. The description and results of these tests follow.

Varying Feed Pressure Doesn't Affect Performance

To investigate the effect of changing feed pressure on the cyclone washer, a series of tests were made varying the feed pressure with all other conditions held constant. The separation curve for two runs made on the cyclone at 10 and 20 psi feed pressure is shown in figure 7. As can be seen from the curve, no significant change in washing gravity or efficiency occurred for only one curve can be drawn through the two sets of points. It can be concluded that feed pressure above a certain minimum is not a factor in performance. One of the references cited states: "The specific gravity of separation and the yield of the cleans increase slightly with increasing pressure." This particular reference used five psi minimum. Fuel Research Institute of South Africa in one of their papers on the washing cyclone also established five psi as the minimum pressure. Dutch State Mines uses about 8½ psi feed pressure. (1.3 sp gr liquid.)

Coal-Medium Ratio Investigated

The coal-medium ratio has been the subject of much discussion for it is recognized that washing with a minimum of medium in circulation would minimize the media cleaning system. Various investigations have been made and it is generally believed that at least five or six to one medium to coal by weight is required to wash bituminous coal at 1.45 gravity. Such a relationship is based on a specific gravity of the feed of 1.30 using the natural tendency of the cyclone to wash at a specific gravity higher than the feed gravity.

Orifice Variations Affect Separation Gravity, Tonnage Processed

Varying the overflow and underflow orifices of a washing cyclone affect principally the separation gravity and the tonnage processed. Increasing the size of the overflow orifice causes an increase in the washing gravity; a decrease in underflow orifice size has the same effect. Increasing the feed orifice causes little change in washing gravity until the capacity of the underflow or overflow orifice for removing the products of the cone is exceeded. Changes in orifices cannot be made freely without considering the effect on the sharpness of separation. Changes in the underflow orifice have the most effect on the washing cyclone. Figure 8 shows the effect of changing the underflow orifice on a cyclone while holding other conditions constant.

Bituminous Coal Performances Cited

Figure 9 shows the results of a washing cyclone test on a ¼-in. by 0 raw coal using a medium of magnetite at 1.26 sp gr. The specific

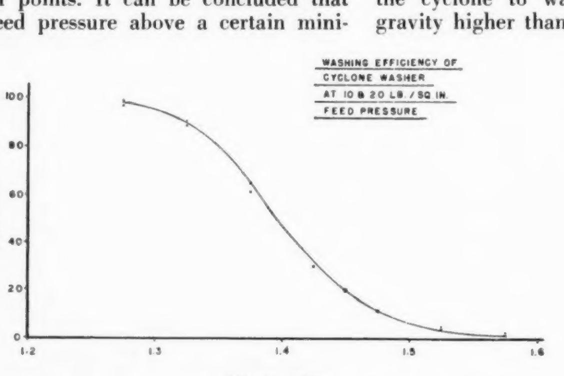

Fig. 7. Investigating the effect of changing feed pressure on the cyclone washer. Since only one curve can be drawn through the two sets of points, it can be concluded that feed pressure above a certain minimum is not a factor in performance

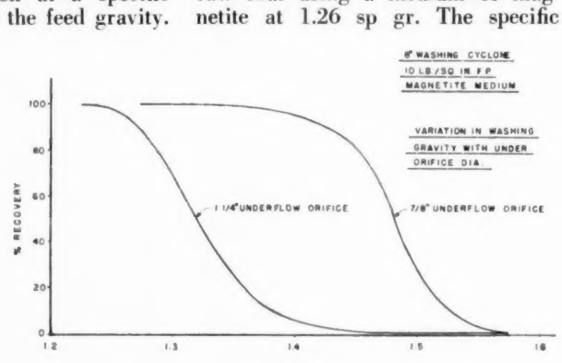

Fig. 8. The effect of changing the underflow orifice on a cyclone while holding other conditions constant

Table I. Data for figure 9. The specific gravity of the overflow slurry was 1.22 and the underflow specific gravity was 1.51

Gravity	Size Increments in U. S. Mesh							
	¼ × 4	4 × 8	8 × 10	10 × 18	18 × 35	35 × 60	60 × 120	120 × 200
1.25/1.30	97.9	95.0	93.6	94.5	92.9	95.8	96.2	96.0
1.30/1.35	83.5	79.4	79.5	85.9	84.2	89.7	91.0	89.6
1.35/1.40	16.0	16.5	21.7	18.1	51.2	87.5	92.0	92.5
1.40/1.45	—	1.2	2.8	11.0	26.2	72.0	86.5	90.0
1.45/1.50	—	—	0.2	1.5	20.6	57.5	83.9	90.9
1.50/1.55	—	—	—	—	2.1	5.7	20.3	38.4
1.55/1.60	—	—	—	—	1.5	2.7	18.7	38.0
1.60 – S	—	—	—	—	0.2	0.2	0.8	0.3

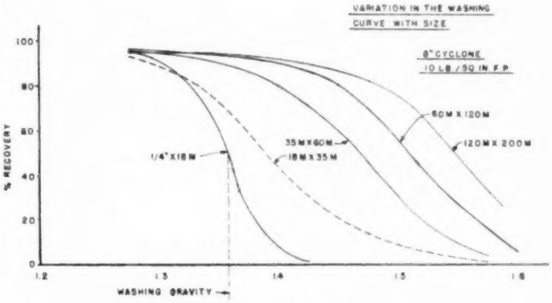

Fig. 9. Results of a washing cyclone test on ¼-in. by 0 raw coal using a medium of magnetite at 1.26 sp gr. The curves show the variation in washing efficiency with particle size. See table I for the data from which the curves were developed

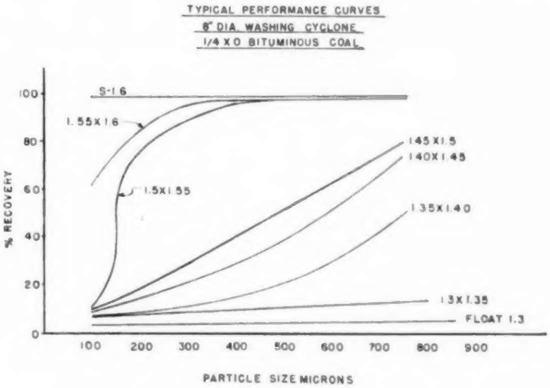

Fig. 10. Data from table I are plotted in the same manner as the curve shown in figure 3. The similarity is apparent showing the validity of the reasoning used in the writer's explanation of the operation of the cyclone washer. See text for full story

gravity of the overflow slurry was 1.22 and the underflow specific gravity was 1.51. The curves show the variation in washing efficiency with particle size. Table I shows the data from which the curves were developed.

On figure 10 the data are shown plotted in the same manner as the curve shown in figure 3. The similarity is apparent and is sufficient evidence of the validity of the reasoning used in the writer's explanation of the operation of the cyclone washer.

Tests have also shown that the shape of the washing cyclone separation curve varies very little with washing gravity or the amount of near-gravity material present in the feed. Consequently, the curves in figure 9 can be used to predict the products of a cyclone washer at any separation gravity merely by adjusting the specific gravity scale as shown.

Washing Cyclone Performs Equally Well on Anthracite

While the preceding data have been given in terms of washing bituminous coals, the washing cyclone can perform equally well on anthracite coal. The results given in table II were obtained in an eight-in. cyclone in the Heyl and Patterson laboratory with anthracite culm bank material. The data show effective washing down to 100 mesh on this sample. The washing gravity was 1.90 with a medium gravity of 1.30. A second run made on similar material at a medium gravity of 1.50 produced a washing gravity of 2.05. The results of this run are shown in table III. The fact that the cyclone can wash a wide size range of anthracite coal in one washing vessel is also a very definite advantage.

These tests contributed information which led to the purchase of a dense medium plant incorporating washing cyclones by a prominent anthracite producer. The plant is under construction and will be in operation this summer.

Media Recovery Circuit—Most Difficult Design Problem

The media recovery circuit used with a washing cyclone plant is actually the most difficult design problem for the preparation engineer. The classic dense media circuit for coarse coal as shown in the block diagram in figure 11 will be used with modifications for a washing cyclone plant. Since separations at ¼ mm to ½ mm will be required in the desliming and media recovery circuits, the separations are more difficult than for coarse coal washers.

The raw coal desliming step can best be accomplished by the use of a combination of sieve bends and pool washing type screens. The sieve bend permits a preliminary sizing of the material at low cost and a minimum of space and power. A vibrating screen on the sieve bend product is required in order to further dewater the cake and remove additional fines before the coal is placed in the washing cyclone feed sump.

Cyclone Selection Depends on Size Distribution of Coal

The size and number of cyclones required for the washing step will depend upon the size distribution and washability of the raw coal. Large diameter cones can be used—that is, greater than 14 in. diam—where the feed consists of material greater than one mm. For bituminous coal washers for the ¼ in. to 28-mesh range, the 24-in. cyclone would have very little difficulty matching the performance shown in the laboratory tests in this article. For material predominantly minus one mm in size, such as the anthracite solids shown in tables II and III, a 14-in. cyclone should be used. The 14-in. unit can process approximately 25 tph and the 24-in. cyclone can process approximately 50 tph of raw coal solids.

In determining the number of cyclones used for a given washing job, extreme care should be used. A washing cyclone designed to use 1.30 sp gr medium to wash at 1.45 gravity requires that the overflow and underflow orifices have a fixed relationship. It is possible in selecting the sizes of orifices to choose an underflow orifice too small to pass high

refuse loads. It then would be necessary to increase the underflow orifice diameter to pass the high refuse loads and at the same time to increase the medium gravity in the feed to obtain separation at the same washing gravity. For design purposes, the washing gravity should be as close to the feed gravity as possible, thus minimizing the concentration of the medium by the cyclone. If this design basis is used, the underflow ori-

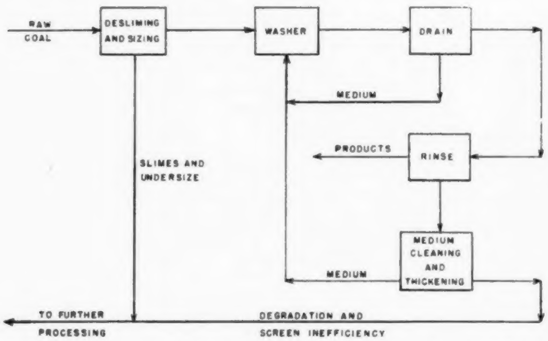

Fig. 11. Classic dense media circuit for coarse coal. It will be used with modifications for a washing cyclone plant

Table II. Results obtained in an eight-in. cyclone with anthracite culm bank material. The washing gravity was 1.90 with a medium gravity of 1.30; yield was 67 percent. Data show effective washing down to 100 mesh on this sample

Size	Feed		Clean Coal		Refuse	
	% Wt.	% Ash	% Wt.	% Ash	% Wt.	% Ash
9 × 16	4.3	16.7	4.9	7.7	3.0	75.8
16 × 32	32.3	20.9	33.5	10.0	30.0	71.7
32 × 60	39.1	33.2	39.9	10.3	38.0	79.8
60 × 100	20.0	76.6	18.9	18.7	22.0	87.5
100 × 150	4.3	75.3	2.8	40.4	7.0	95.0
Totals	100.0	32.5	100.0	13.0	100.0	82.0

Table III. Results of a second run made on anthracite culm bank material with an eight-in. cyclone at a medium gravity of 1.50. A washing gravity of 2.05 was produced and the yield was 80.9 percent

Size	Feed		Clean Coal		Refuse	
U. S. Mesh	% Wt.	% Ash	% Wt.	% Ash	% Wt.	% Ash
+ 9	0.5	11.1	0.6	11.0	—	—
9 × 16	4.0	18.5	4.5	10.4	2.1	87.5
16 × 32	33.4	23.2	35.5	12.3	24.7	87.5
32 × 60	39.9	31.0	38.4	13.6	45.8	91.1
60 × 100	17.7	38.4	16.5	20.0	23.0	92.5
100 × 150	4.5	16.5	4.5	47.8	4.4	91.7
Totals	100.0	31.6	100.0	15.9	100.0	91.3

	Specific Gravity	Recovery
Float—	1.5	99.9
	1.5 × 1.6	99.9
	1.6 × 1.7	99.9
	1.7 × 1.8	99.6
	1.8 × 1.9	96.0
	1.9 × 2.0	85.3
Sink—	2.0	00.5

Fig. 12. Washing cyclones in advanced stage of installation. The cyclone plant will predominate for the difficult washing jobs, particularly where there is an excessive amount of near gravity material, where the required washing gravity is low, and where the washing characteristics of the raw coal vary within wide limits

fice will be capable of passing varying refuse loads without difficulty.

The products of the cyclone should be drained of as much media as possible before the remainder is diluted with spray water. The medium immediately drained from the coal can be directed back to the dense medium sump without further processing. The medium remaining on the coal of course is a function of the size distribution and particle shape but in general upwards of 90 percent of the medium will drain from the products.

Pool washing type screens are being used for the rinsing steps on the iron range in washing cyclone plants where non-magnetic ores are processed. For the washing of fine coal to ½ mm, this type of screen is best suited for the removal of the medium adhering to the particles after drainage. These screens work on the principle of reslurrying the screen cake so that the medium adhering to the coal particles is diluted and, because of its high specific gravity, drains from the coal quite rapidly.

The medium and coal solids contained in the rinsing screen effluent must be separated, the media thickened for return to the washing cyclone feed sump, and the contaminating coal solids produced by screen inefficiency and degradation removed from the washing cyclone circuit. There are many variations and innovations used on this part of the circuit, for the equipment required is expensive and occupies a large amount of space. Thickeners, both the cyclone and static type, can be used to thicken the medium and coal solids ahead of the magnetic separators. Magnetic separators are sized on a volume basis up to certain limiting concentrations so that thickening the feed reduces the size of the magnetic separator installation. The concentrate from the magnetic separators can be added directly to the washing cyclone feed sump without additional thickening. The tailings from the magnetic separator and the effluent of the raw coal desliming screens are removed from the circuit to minimize build-up of fine coal solids in the circuit.

Density Controls Limit Excessive Swings in Medium Gravity

Density controls may be added to the cyclone washing circuit to limit excessive swings in medium gravity. These may either be automatic or manual depending upon the operator's preference. In a washing cyclone circuit, very little magnetite is held in storage in any vessel so the absolute need for automatic controls has not been established. There are any number of specific gravity control methods which can be used for this service.

After many years of testing, the washing cyclone has been introduced to the coal operators as a new and efficient tool for fine coal preparation. The washing cyclone, undoubtedly, will find a large and receptive market because it has many advantages over presently used processes. Of course, not all future fine coal plants will employ the washing cyclone; however, the cyclone plant will predominate for the difficult washing jobs, particularly where there is:

A) An excessive amount of near gravity material.
B) Where the required washing gravity is low.
C) Where the washing characteristics of the raw coal vary within wide limits.

For these difficult conditions, the washing cyclone is undoubtedly the most practical fine coal cleaning device known at this time.

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Rock Mechanics

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THE science of rock mechanics, a rational physical description of how rocks behave under stresses, is in its infancy. Rock mechanics has never been utilized as the sole basis for the design of an operating mine, but there is no reason for not believing that ultimately mine design can be placed on the same reasonably firm scientific and engineering foundation that the design of buildings, highways and bridges now enjoy.

The transition will not and cannot be abrupt. It is certain though, that the great body of principles and facts which form the embryonic science of rock mechanics will contribute significantly to this transition although specific applications may not yet be apparent.

Nature of Rock Mechanics

The principles of rock mechanics delineate how rock behaves when it is subjected to mechanical stresses, both static and dynamic. The rock may be an in situ ore body through which mining operations are progressing, it may be a small pebble which is to be crushed, or it may be a sizable block to be used as a structural member in a building.

The problem pursued by the rock mechanician is an age old one: to predict what will happen when a certain thing, usually quite specific, is done to the rock. In the various mining operations the in situ rock is greatly disturbed, producing a multitude of reactions within the rock; some of which can be used to advantage and others of which raise serious problems. The ultimate goal of the rock mechanician is to describe accurately what will happen in all situations which the mining engineer is likely to encounter.

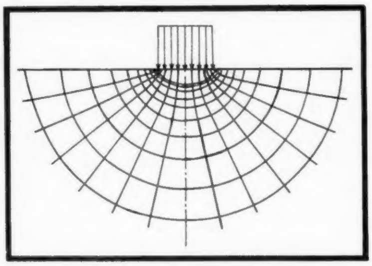

Fig. 1. A typical stress field. This field would be produced by a strip load acting on a semi-infinite plane

The science of the strength of materials began about 1650 with Galileo,[1] who established the first laboratory test for determining the strength of materials. He simply affixed a bar of material rigidly at one end and pulled on the other end until the bar broke. This test is now, of course, done routinely in all materials testing laboratories.

Relationship of Stress to Strain

Later Hooke (*circa* 1680) in England discovered the physical law that bears his name. This states that: as the extension, so the force; or when only mildly stressed, most solids will extend themselves in direct proportion to the magnitude of the applied stress and on removal of the stress will return to their original configurations. No real material behaves exactly in this way, but the approximation is a good and exceedingly useful one. Hooke's law, by establishing a definite and conveniently simple relationship between stress and strain, both of which are amenable to precise mathematical expressions, provided the keystone for the mathematical theory of elasticity.

The substantial activity among applied mathematicians[2,3] which it initiated still continues undiminished, the problems becoming ever more complex. The usual problem is, knowing the distribution of the applied stress, to compute the stress or strain at every point within the body, the body frequently being some structure of engineering interest but occasionally simply chosen to satisfy the mathematician's desire to solve an interesting and challenging problem.

As long as a definite relationship is assumed between stress and strain, it is immaterial whether stress or strain is used as the parameter: knowing the distribution of strain, the distribution of stress which is causing it can always be found. The stress distribution so determined can then usually be best displayed graphically as a stress field, with the lines giving both direction and magnitude of stress (figure 1).

Measurement of Stresses

Practical problems abound that even the most astute of mathematicians cannot hope to solve. Fortunately, in recent years the experimental stress analyst has developed two powerful tools, photoelastic techniques and electric strain gages, both invaluable for determining the distribution of strain, and consequently stress, within complex bodies.

Photoelastic observations[4] depend upon the fact that, in a transparent nonuniformly strained body, light travels at a different velocity through the strained regions than through the unstrained regions, the difference in velocity being strictly proportional to the strain. The waves of light, traveling at different velocities interfere with one another to produce light patterns characteristic of the inhomogeneities in strain.

Detailed analysis of the light pattern gives the state of strain, hence stress, at every point in the body. The method only works well with two dimensional bodies such as plates where the strain can be considered uniform across the thickness of the plate. Certain photoelasticians have been clever enough to successfully apply the method to a few three dimensional bodies.

The electric strain gage,[5] invented in the late 1920's, operates on the principle that straining will change the electrical resistance of a small wire because of the dimensional changes in the wire. Such gages are rigidly affixed to the surfaces of bodies which are then stressed in some preselected

way. The gages usually read only surface strains, it seldom being physically possible to mount them inside the body under study. Whereas photoelastic techniques are limited to elastic, recoverable strains, the electric strain gage will measure permanent deformations.

Each method, mathematical, photoelastic or strain gages, has severe limitations so that it is virtually impossible to determine precisely the state of stress and state of strain in most situations of engineering importance. The closeness of correspondence between the theoretical state and the actual state will be governed by a wide variety of factors.

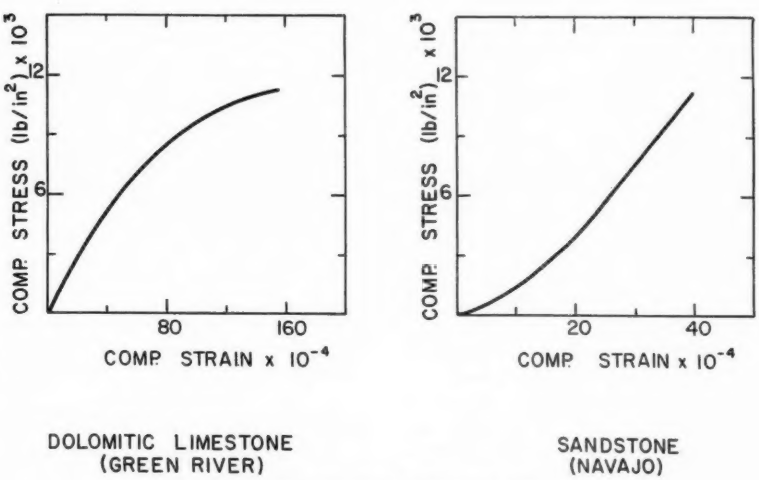

Fig. 2. Stress-strain curves for sandstone and limestone

Rock Failure Not Elastic Process

Over the years, the theoretical and experimental stress analysts have built up great funds of information on a wide variety of problems. In mining studies, emphasis has been on the description of stress and strain fields around openings of many types and configurations simulating mines:[6–9] single openings, round, square, and elliptical; and sets of multiple openings. Since these studies describe only the elastic behavior of structures under a preselected and hypothetical set of stress conditions, the results cannot be directly applied to the practical design of mine openings.

Rock failure, the major concern of the mining engineer, cannot quite obviously be an elastic process, being strictly irreversible. Thus, Hooke's law does not apply and photoelastic solutions to problems are no longer valid. The problem is actually the description of qualities of failure, crushing, plastic flow, fracturing; and the establishment of criteria to define under what specific conditions each quality of failure will be initiated and propagated. It is in this area that the theoreticians and experimentalists have not contributed significantly.

Criteria of Failure

The problem in mining is to extract specific segments of rock, leaving the remainder in place, in such a way as to maintain complete control at all stages of the process. Complete control involves either preventing the collapse of mine openings or deliberately initiating their collapse.

Although much effort has been put forth,[10] it is still impossible to describe precisely and accurately in a scientific manner the state of affairs that will initiate and propagate failures.

Generally, in rock, concentrations of high stress with their pronounced stress gradients produce strains exceeding the elastic endurance of the rock. Fracturing or crushing will then occur relieving and redistributing the stress; the failures continuing until the body comes to elastic equilibrium.

There are many qualities of failure. A stressed rock may fail simply by deforming slowly under an applied load until the load is distributed such that it is no longer able to produce further deformation. Loaded beams of potash or ice will flow in this fashion. Or the stressed rock may fracture almost explosively without significant prior deformation when the load reaches a certain level. The nature of these inelastic behavior patterns vary widely among rocks, some rock becoming more resistant to deformation as the stress increases and others less resistant.

The greatest room for advancement in rock mechanics lies in developing sound theory and amassing experimental data which can form the basis for the establishment of unambiguous and realistic criteria for failure.

Stressed Rocks Nearly Obey Hooke's Law

Small masses of rock, the kind generally used for laboratory tests, are usually reasonably coherent and isotropic. Small rocks when mildly stressed act as quasi-elastic bodies,[11] almost but not quite obeying Hooke's law: the stress-strain curve is seldom perfectly straight, being sometimes concave upward, sometimes concave downward and occasionally having a point of inflexion.

A sandstone, with its unfilled interstices which quickly fill up during early stages of compression, exhibits a stress-strain curve bending upward (figure 2); while limestone, with its interstices already filled with soluble material, shows great resistance to deformation during early stages, failing gradually at first but more rapidly once substantial deformation sets in.

Rocks have compressive, tensile, and shear strengths which are fairly constant from sample to sample of the same rock. They are weak in tension, a few hundred pounds per square inch breaking strength, but thirty to seventy times as strong in compression. Values of tensile and compressive strengths of three typical rock types are listed below.

Rock Type	(A) Compression Strength (lb/in^2)	(B) Tensile Strength (lb/in^2)	A/B
Granite	28,000	410	68
Sandstone	18,000	310	58
Limestone	10,000	400	25

Under fairly rapidly changing loads, rocks fracture in a brittle fashion, there being no flow of the rock mass. The path the fracture will take can usually be associated with certain shear or tensile components of the stress field.

Study of Large Rock Masses

Large, in situ rock masses are heterogeneous, being rife with veins, jointed structures, fissures, faults, and changes in composition. This is particularly true of those rocks contiguous to ore bodies for it is these very inhomogeneities which caused the ore to be deposited in the first

place. The distribution of stress and strain within such a conglomerate mass could not conceivably be simple; the great inhomogeneities in stress and strain must exist.

Usually the theoretical rock mechanician has no alternative but to treat the rock mass as homogenous. He must then decide whether the mass is acting like a great body of fluid, with hydrostatic pressure being the principal stress parameter; whether it is acting like an elastic solid with lateral constraints governed by Poisson's ratio; or, whether it is acting like a solid without any lateral constraint. Having made his choice, he then solves his problem. Qualitatively, the solutions are not vastly different; quantitatively, computed critical stresses may differ by factors of two or three depending upon the assumptions made.

There is a great need for the experimental determination of the distribution of stresses in in situ rock. Hast[12] has made an excellent start in this direction. He places a specially designed strain gage in a large rock mass and then relieves the stresses in the rock by cutting away from the parent mass that portion which contains the gage. The actual pre-existing stress field in the area in which the mine openings are to be made must be known before mine design can be put on a rational basis.

Whatever may be the state of stress and strain within the rock mass, introduction of mine openings will change them, often drastically. The main effect will be to create pronounced concentrations of stress close to the openings as illustrated in figure 3. Failure will ensue if the rock is not physically strong enough to withstand these new concentrations of stress.

The problem in mine design is to make the openings of such shapes and so oriented that potentially damaging and dangerous concentrations of stress do not develop during or subsequent to the operation.

Loose or Semi-Loose Rocks Surround All Mine Openings

The practical mining engineer naturally objects to these theoretical studies. Mine openings are not regular geometrical shapes, surrounded by isotropic, homogeneous rock; the rock sides of the openings are not smooth but irregular; the skin is frequently cracked and broken up, relieving any stresses that might have been built up during production of the opening. As in most practical engineering problems, theory and corollary experiment must be combined in proper proportion with practical know-how to form the best possible picture of the real situation.

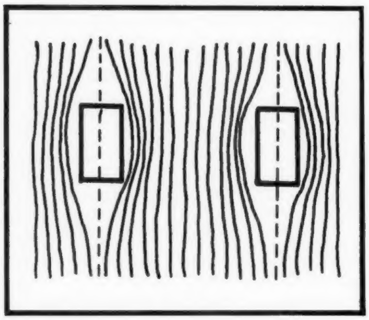

Fig. 3. Disturbance of stress distribution by introduction of two mine openings

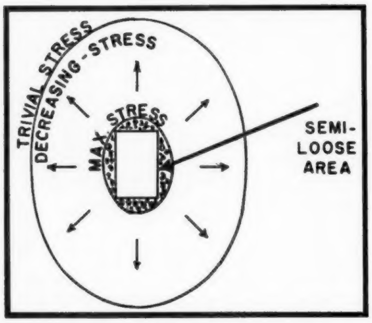

Fig. 4. Probable stresses around a rectangular mine opening

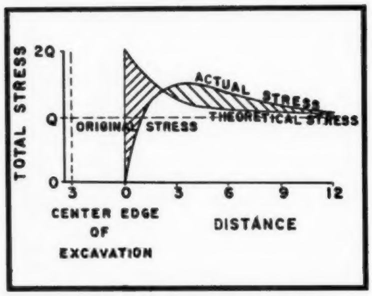

Fig. 5. Comparison of theoretical stress distribution and the probable actual stress distribution (isotropic homogeneous plastic body assumed)

Spalding[13] has one realistic approach to the problem which is representative of the way in which rock mechanics must eventually find its greatest application to mine design. He postulates that the rock around the opening relieves stress by failing, the result being that all mine openings are surrounded with a zone of loose, or semi-loose, rock outside of which is solid rock under increased stress (figures 4, 5).

Breaking up of the rock leads to arching, the effect of which is to change the shape of the gallery from the inefficient irregular section excavated to one better adapted to withstand the extra stresses caused in the rock. He goes further then and considers qualitatively the influence of faults, fissures, and other geologic discontinuities on the changing stress fields accompanying the progress of a mining operation such as the extraction of a lens shape ore body contiguous to a fissure. He is able, by making a few reasonable and relatively simple assumptions to explain the origin of certain common types of rock bursts and other structural failures.

Future Outlook

It is inevitable that in the years ahead mining will become more of a science and less of an art. Mines will be designed on a rational scientific basis just as other important structures are now. The designers of the mines will be engineers, not scientists, the scientist's task being to provide the scientific foundation for the procedures used by the engineers. The science of rock mechanics will contribute heavily, with many of its most significant contributions coming about in unforeseen and unexpected ways.

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Three Principles of Comminution

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The study of comminution theory is about 100 years old. Numerous experiments have been performed, mathematical studies made, and papers written, but the subject still generates more heat than light. There is no general agreement as to the correct theory, and little agreement between some of the theories and commercial crushing and grinding operations. Perhaps a fresh attempt to enunciate the basic principles involved is in order.

THE objective is the discovery of the correct relationship between useful energy input and the product particle size made from a given feed size. This would seem to be fairly simple of attainment, but it has proved far otherwise.

Much of the difficulty stems from disagreement as to the nature or definition of useful energy input and of product particle size. The useful energy input will be discussed first.

The First Principle

Energy input is required to reduce particle size, so that all divided particles of finite size have by definition required energy input in their formation. Feed particles to comminution represent a certain energy register, or energy input level, and the energy input during comminution should be added to the energy register of the feed before comminution in order to obtain the energy level represented by the comminution product. In other words, the comminution energy register is zero only for particles of infinite size, and the energy input required for comminution from a finite feed size is only a fraction of the total energy input represented by the product. This is of sufficient importance to be called the first principle of comminution analysis.

If w represents the specific input during comminution from a feed particle of size f to product particles of size p, then

$$w = \frac{k}{p^n} - \frac{k}{f^n} \qquad (1)$$

where k is a constant and n is an exponent to be discussed later. An equation which can be resolved into the general form:

$$\textit{energy input} = \textit{energy register of product} - \textit{energy register of feed}$$

should be used in analyzing all comminution problems. If this first principle is not followed the results will be distorted to a false zero energy register.

The term "energy register" is used in this article to designate the amount of energy which has passed through the material as strain energy and registered as particle size reduction. It does not correspond to energy content as usually understood.

The following calculation of a typical case illustrates the erroneous results obtained when the energy register of the feed is disregarded, which means that the first principle is disregarded. A hypothetical ball mill feed has a product size of 1000 microns and an energy register of four kwh per ton. It is ground with energy input increments of two kwh per ton with product sizes as listed below.

KWH Per Ton			
Feed Energy Register	Product Energy Input (W)	Product Energy Register	Microns Product Size
4	0	4	1000
4	2	6	445
4	4	8	258
4	6	10	160.5
4	8	12	111.0
4	10	14	81.6

In figure 1 the product size in microns is plotted on log-log paper against the product energy register as line A and against the product energy input as line B. Line A is in

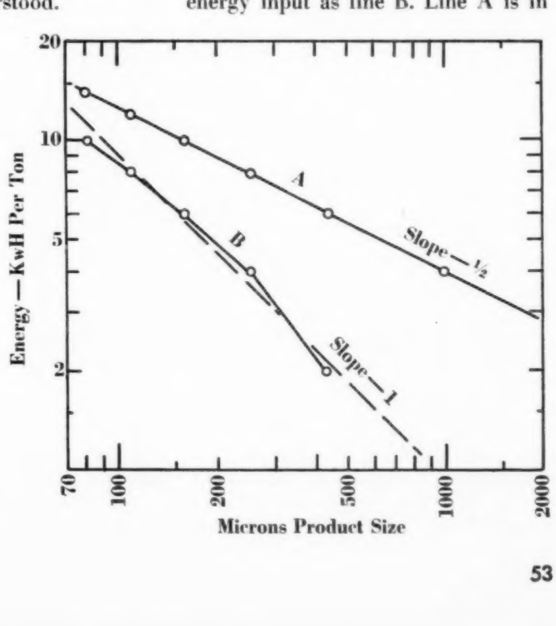


Fig. 1. Product size in microns plotted against product energy register (line A) and against product energy input (line B)

accord with the first principle; it is straight with a slope of $-\frac{1}{2}$ as required by the Third Theory of Comminution.[1] Line B represents the same data but is plotted without regard to the energy register of the feed. Its slope is approximately minus one, and it indicates erroneously that the grinding data listed are in approximate agreement with the Rittinger Theory.[1]

Disregarding the energy register of the feed in comminution calculations is rather like disregarding a person's present age in computing his future life expectancy, with strain energy units taking the place of years.

Disregard of the first principle has been quite common in analyzing comminution experiments. Especially in test results which support the Rittinger Theory, that the useful work input is proportional to the surface area produced, has the energy register of the feed been commonly assumed to be zero.

Definition of Useful Energy

Another item in much dispute concerns the definition of useful energy. Proponents of the Rittinger Theory have tended to equate it with the surface energy of the exposed surface area, even though this amounts to a fraction of the order of 1/1000 of the actual energy input required for breakage.

In ordinary crushing and grinding rock particles absorb strain energy and are deformed under compression or shear until the weakest flaw in the particle fails with the formation of a crack tip. This minute change of shape causes other crack tips to form, and the particle breaks, releasing the bulk of the strain energy as heat.

It may be that some time in the future a method of breaking rock will be developed which does not require strain energy. However, at present all commercial crushing and grinding, and nearly all comminution laboratory testing, are accomplished principally by the conversion of mechanical energy into strain energy into heat. It seems to the author that we must deal with the efficiency of this conversion in relation to the efficiency of particle size reduction in any comminution studies of practical importance. This does not mean that the search for a more efficient method not requiring strain energy conversion should cease, but it does mean that studies which do not involve strain energy conversion have little or no practical application at the present time. The amount of effective strain energy conversion is designated here as the energy register.

Evaluation of Particle Size

If there is little agreement on useful energy input in comminution, there is still less on measurement and evaluation of the product and feed sizes. A comminution product contains particles of all sizes ranging down to the grind limit at 0.1 micron and possibly below. The natural distribution of these sizes, and the effective summation of the product size into a simple term for evaluation of the work done, constitutes a study which could fill volumes and cannot be completely reviewed here.

The most popular method of representing size distribution analyses at the present time is the log-log plot, in which the percent passing y is plotted as ordinate on log-log paper against the micron size x. A straight line on this paper follows a *power law*, in which

$$y = 100\left(\frac{x}{k_{100}}\right) \qquad (2)$$

where k_{100} is the intercept of the extended straight line with 100 percent passing at the top of the chart, and α is the slope of the line. This is the Schuhmann equation,[2] or the Gates-Gaudin-Schuhmann equation, as it is sometimes called.

The surface area Sc in square centimeters per gram of cubical particles of density ρ with 100 percent passing k_{100} microns and slope α to a grind limit of L microns is

$$Sc = \frac{60{,}000\,\alpha}{\rho k_{100}(1-\alpha)}\left[\left(\frac{k_{100}}{L}\right)^{1-\alpha} - 1\right] \qquad (3)$$

The trouble with the Schuhmann power law equation is that the plotted size distributions of most complete comminution products do not follow the indicated straight line. Instead, they form long sweeping curves in the upper portion of the plot, which tend to approach tangency with the 100 percent passing line at the top of the chart rather than to intersect it.

The tendency of the plotted log-log size distribution line to become tangent to the 100 percent passing line suggests that the proper size distribution law is of the *exponential* type with a variable exponent rather than of the *power* type with a fixed exponent. Equations of the exponential type have been developed by Rosin-Rammler[3] and later by the author.[4]

The Rosin-Rammler type of plot has been much used in Europe, particularly in analyzing coal. Its size distribution line tends to be straighter than the Schuhmann line, but still usually shows some curvature. Its equation is

$$100 - y = 100/e^{Bx^n} \qquad (4)$$

where B and n are constants.

The Third Theory size distribution plot[4] requires modified semilog plotting paper. The size distribution line equation is

$$100 - y = b/e^{ax} \qquad (5)$$

where x represents the total work input or energy register, b is the $100 - y$ intercept, and a is a constant. Actual homogeneous size distribution plots appear to follow the straight line of equation (5) quite well, and natural or induced grain sizes or fines removal are definitely indicated by curves in the plot. According to the Third Theory of comminution the useful work input is proportional to the crack length produced, and a method for finding the crack length from the size distribution plot is given.[4]

Specific Energy Input

Some value which is proportional to the specific energy input, or energy register, must be assigned to the feed and product before the general comminution problem can be solved. Many different values have been used.

Proponents of the Rittinger Theory tend to use some surface area value. The surface areas may be measured directly by the gas adsorption method, or the air permeability method, or they may be calculated from a variety of particle size distribution measurements by different methods, including that of equation (3) with corrections for variations in particle shape. The calculated values usually require some lower limit of particle size, such as the grind limit at 0.1 micron.

However, the primary consideration in most comminution operations, and especially in the grinding of ores and minerals, is the size of the coarser particles in the product. The k_{100} intercept of the Schuhmann extended size distribution line on the log-log plot has been much used as a working criterion of the comminution energy register of the product, and sometimes of the feed.

Since the actual plotted size distribution line usually departs widely from the k_{100} intercept, use of the intercept is a better criterion of the fine particle sizes than of the coarse sizes. In the Third Theory equation the actual 80 percent passing size or K_{80}

point is used.[1] If P represents the size which 80 percent of the feed passes W is work input in kilowatt hours per short tone, and Wi is the work index parameter, then

$$W = \frac{10\,Wi}{\sqrt{P}} - \frac{10\,Wi}{\sqrt{F}} \qquad (6)$$

When any three of the four quantities in this equation are known the fourth can be found by transposing the equation. The energy input in joules or watt-seconds per gram is obtained by multiplying kilowatt hours per ton by 3.97.

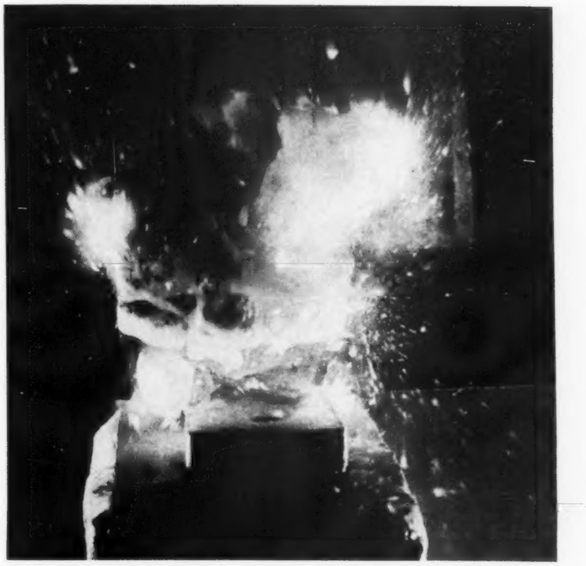
The Second Principle

The Third Theory equation follows the first principle that the energy input equals the energy register of the product minus the energy register of the feed. It has proved extremely useful in solving commercial crushing and grinding problems. More than 2000 work index measurements have been made by laboratory testing, and most of these have been used in commercial installations.

The general comminution equation (1) has the product and feed sizes raised to an indeterminate exponent. In the Third Theory equation the value of the exponent n is one-half, while according to the Rittinger Theory its value is unity. According to the Kick theory its value is zero, and the required specific work input is proportional only to the ratio of the feed size to the product size.

Since the surface area of a ton of particles of diameter d is proportional to $1/d$, the Rittinger work input is proportional to the surface area increase; and since the crack length is proportional to the square root of the surface area the Third Theory work input is proportional to the crack length increase or to $1/\sqrt{d}$. The actual value of the exponent n can be found by analyzing any given set of comminution data.

Most commercial crushing and grinding installations when analyzed in accordance with the first principle, give exponents in the neighborhood of one-half, and the exponent appears to be exactly one-half for homogenous materials. However, variations at various particle sizes in the efficiency of reduction machines, in hardness, and in natural grain sizes, cause variations in the energy input required. It is theoretically consistent and has been found convenient, to let the exponent n remain at one-half in all cases and vary the work index parameter Wi at different particle sizes to account for these variations. However, the calculated crack length produced per unit of energy input ordinarily does not vary with the work index parameter.[4] If the material hardness and reduction efficiency are constant at different particle sizes the work index value is observed to remain with the exponent one-half.



Piece of milky quartz photographed at the instant of breakage in the Allis-Chalmers Research Laboratories' twin pendulum impact tester. Some fragments are already completely detached, while others are being formed by rapidly deepening crack tips at the left. The instrument is used to measure the work input and work index in crushing

The second principle of comminution theory is that the total effective work input required to break a stated quantity of rock is regularly proportional to the total length of the crack tips formed, or the square root of the total surface area formed, from a theoretically infinite feed size. According to the second principle the particle size exponent in equations (1) and (6) is one-half.

In practical grinding operations the numerical difference between the specific work input required with a piece of rock feed weighing one ton and a piece of theoretically infinite size is insignificant. The second principle can accordingly be rested as follows: *The effective kilowatt-hours required to grind a ton of rock from one piece to any product size d is regularly proportional to* $1/\sqrt{d}$.

Some variations are to be expected because of irregularities such as natural grain sizes and other inhomogeneities of the material or in the reduction operation. These can be conveniently redacted by variations in the work index parameter.

Evaluation of Irregular Feed Sizes

The first principle requires that the effective feed particle size be evaluated on the same basis as the product particle size. If the feed consists of a natural crushed or ground material containing its natural quota of fines the procedure is exactly the same as that used for the product. However, if the feed has had part or all of the fines removed, or if it consists of particles limited in size between two screen openings, or if, as in some comminution experiments, it consists of particles of a special prepared shape such as cubes or spheres which differs greatly from the shape of the broken product particles, special methods are necessary to evaluate the effective feed size on the same scale as the product size.

In the present state of knowledge these methods of analyzing the effects of limited feed sizes and special feed particle shapes are necessarily empirical, but should always be guided by the first principle. In practice this means that the equivalent particle size of special feeds should be evaluated to yield the same exponent n which has been found valid with regular feeds containing their natural fines; always provided that the feed evaluation obtained in this manner appears logical and consistent.

If part of the fines have been removed from the feed the value of F in equation (6) is increased somewhat above the 80 percent passing size, and if it consists of particles all of one size it is increased still further. If the feed consists of spherical particles of one size, F is approximately equal to the diameter of the spheres in microns.

The Third Principle

Size reduction by crushing or grinding consists of a succession of multitudinous breaks of individual

particles. Its analysis should start with the breakage of separate pieces, which can be integrated into the complete comminution process.

When several pieces of the same size and shape of the same brittle material are broken individually under compression a surprising range of breaking strengths is obtained. The hardest piece may require several times as much energy input as the apparently identical one which is most easily broken. The breakage of each piece is evidently controlled by its individual structure and orientation of zones of weakness, re-entrant angles, and incipient cracks, which may be collectively called flaws. A flaw signifies a local weakening of the rock structure which under strain may develop into a crack tip.

It is also observed that the amount of breakage produced is consistently proportional to the energy input required to break. The hardest piece will form many more product particles than the piece of the same material which fails most easily. A single pronounced flaw properly oriented with respect to the compression contact points will cause a piece of rock to break readily into two or three pieces, while its absence will necessitate more energy input to break from more numerous stronger flaws into more pieces. If a brittle cube completely without flaws could be broken by compression evenly applied to opposite parallel faces it would absorb a very large amount of strain energy and should finally fail explosively into a product consisting entirely of fine dust.

The weakest flaw in an individual particle controls the energy input required to break it, and also controls the number of product particles formed.

Reduction Ratio Depends on Flaw Factor

The reduction ratio from an individual particle break, or the particle-feed-size/particle-product-size, is a direct consequence of the particle flaw structure, and is called here the flaw factor *ff*. As the flaw factor increases, the strength of the weakest flaw in the particle increases.

In any crushing or grinding operation where feed particle size F is reduced to product particle size P, and F/P equals the reduction ratio Rf, then

$$Rr = ff \times N \qquad (7)$$

where N is the number of successive single breaks.

The breakage of each rock piece in a series of simliar pieces yields essentially the same work index as that computed from feed and product sizes, even though the individual breaking strengths may vary widely.

The third principle of comminution theory deals with the flaws in individual particles; it states that:

(a) Flaws are present in all size ranges of crushed and ground products.
(b) The weakest flaw in a particle determines its breaking strength and the number and size of the product particles formed.
(c) The weakest flaw in a particle does not determine the specific work input required to reduce it from a stated feed size to a stated product size.

The first principle or comminution theory states that the specific work input done in crushing or grinding equals the energy register of the product minus the energy register of the feed. If the energy register represented by the feed particles is assumed to be zero the results will be distorted. The energy register represents the energy which has passed through the material as strain energy and registered as broken particles.

Feed and product particle sizes can be expressed as the projected size which 100 percent passes, or as the actual size which 80 percent passes. Size distribution lines plot with less curvature exponentially than as a power law on log-log paper.

The second principle states that the effective kilowatt hours required to grind a ton of rock from one piece to any product size d varies as $1\sqrt{d}$.

The 80 percent passing size of a comminution feed with part or all of the fines removed must be increased to compensate for the missing fines.

The third principle states that the breaking strengths of individual particles under compression, and the number and size of the product particles made, but not the work input required to reduce to a state size, depend upon the flaw structure of the particles.

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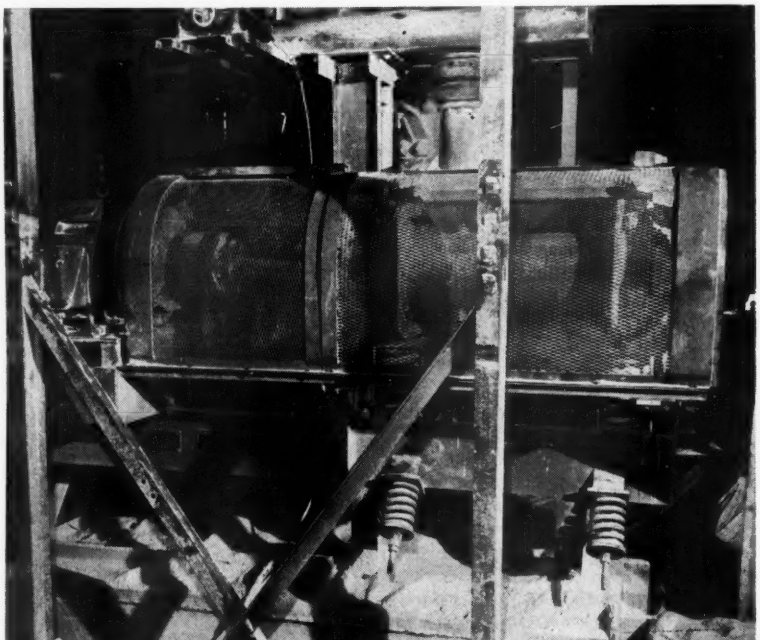

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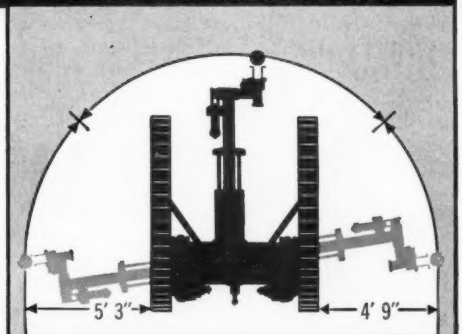

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With its Colonial architecture, P & M's new headquarters building is recognition and commemoration of a proud past. Typical of the company's pioneering instinct, however, is a heat pump for year-round air conditioning

The P&M Story

Fast growing midwestern coal producer pauses briefly to look back before tackling the future

FIRST impressions are lasting impressions—and the first impression you are likely to get upon entering the offices of the Pittsburg & Midway Coal Mining Co. is one of a supreme confidence in an ability to handle any problem at hand. This is quite an impression for a company that is celebrating its 75th Anniversary in an industry where age is often considered synonymous with decay.

Headquartered in the friendly town of Pittsburg, which is tucked away in the southeastern corner of Kansas, Pittsburg & Midway straddles the heart of the continent, with mines in Kentucky, Missouri, Arkansas, Kansas and Colorado. Its productive capacity of 5,000,000 tons annually is backed up by reserves estimated at approximately 477,000,000 tons. The company takes its name from Pittsburg and the little village of Midway, Kan., a watering place used by the cavalry in pre-Civil War days, located appropriately enough midway between Fort Scott and Baxter Springs, Kan.

Chartered in 1885

The Pittsburg & Midway Coal Co., later to be called The Pittsburg & Midway Coal Mining Co., was chartered by the State of Kansas on May 9, 1885. Article III of the charter stated that, "the business of said Corporation shall be transacted in the towns of Pittsburg and Midway, Kansas, and such other places in the United States as the general business interests of the company require."

Article VI stated, "the Capital stock of said Corporation shall be $200,000 to be divided into 2000 shares."

The company's Mine No. 0 had been opened in the latter part of 1884. There is no record of its performance that year, but the State Department of Mines reports that 114,620 bushels of coal (4585 tons) were produced in 1885. The mine worked 76 days that year, with an average of 26 miners employed. Average productivity was 60 bushels (2.4 tons) per man day. Wages were at the rate of 3.5 cents per bushel during the summer and 4 cents during the winter.

Eighteen eighty five was a year of growth, and two more mines were opened. Shaft Mine No. 1 was sunk ¼ mile southwest of Midway and Shaft Mine No. 2 was put down ½ mile northeast of Midway, just west of the Missouri state line. During that year 234,737 bushels (9389 tons) of coal were produced at Mine No. 1 and 32,550 bushels (1302 tons) were produced at Mine No. 2. Both mines were ventilated by ten-ft fans.

Expansion brought problems, however, and early in 1886 at a meeting of the board of directors a motion was made, seconded and passed permitting the president to borrow $25,000 from "Mr. Charles Merriam of Boston" for three years at an interest rate of seven percent. The loan was never consummated, however, and a special meeting was called in mid-April. Minutes of that meeting state, ". . . that for some reason unnecessary and damaging delay is being experienced in obtaining said loan from said Merriam. . . .", and it was resolved to instead borrow $30,000 from National Loan and Trust Company of Kansas City, Mo., for five years at a rate of six percent per year. The loan was covered by two notes, one for $10,000 due in two years and one for $20,000 due in five years.

The young company rolled along, supplying coal to a local domestic market and as railroad fuel, with good years, 25,217 tons in 1886, and bad ones, 1316 tons in 1890, until a move was made in 1895 by a group of insurgent stockholders to gain control of the company. A stockholders' meeting was called April 25, 1895, but was postponed until May 2 because a quorum was lacking. The same situation existed May 2 and another meeting was called for May 4, but this also was adjourned for the lack of a quorum.

Finally a meeting was properly held May 20, with a G. H. Lanyon turning up with 678 shares and one A. H. Lanyon with 220 shares of the 2000 outstanding.

The Lanyons, it might be pointed out, were bankers in the area and also operated lead-zinc smelters and a brick plant.

Reorganized in 1895

It was a busy summer and at a meeting November 6, 1895, in Pittsburg, stockholders approved unanimously a motion to sell "the coal rights, mining property, mercantile stock, credits and business and entire plant situation in Crawford County, Kansas, for the sum of $265,000."

Payment was to be as follows: $199,600 in cancelled stock of the Pittsburg & Midway Coal Company—owned by stockholders in the new company, to be known as the Pittsburg & Midway Coal Mining Company—the assumption of $65,000 in floating debt and the delivery of a claim of $400 against the old company held by the new company.

Pittsburg & Midway Coal Mining Co., capitalized at $200,000, was chartered November 18, 1895, by the State of Missouri. The old Pittsburg & Midway Mining Co. went out of business January 10, 1896.

Production was gradually increased and in 1899 reached 254,495 tons. Then it began to slip, however, and declined to 54,583 tons in 1910. In 1911 a most important turn in events was taken by the coal producer with the acquisition of company control by Charles F. Spencer.

C. F. Spencer was no stranger to coal mining, having operated several small mines with his father, John W. Spencer, near Columbus, Kan. J. W. Spencer, a cavalryman in the Civil War, had homesteaded in southeastern Kansas and became a rancher. He began coal mining after being crippled in a fall from a horse. It is interesting to note that P & M is now mining coal on part of the original Spencer Homestead.

It was C. F. Spencer who started Pittsburg & Midway on the road to the big time. In 1910 he and some other associates had installed a 1½-cu yd shovel with a 50-ft boom near Stippville, Kan., and he was taken with the possibilities of power stripping. The building of the Panama Canal stimulated the development of excavating equipment, and in 1918 the company purchased a six-yd full-revolving power shovel, the first electric shovel ever used in the mining industry.

Strip and underground mining continued in Kansas and was extended into the adjoining states of Oklahoma, Missouri and Arkansas. New mining methods and larger, more efficient equipment were utilized as they were developed.

The company erected its first coal washer in 1931 at Mine No. 10, and in 1933 constructed the first central cleaning plant west of the Mississippi at West Mineral, Kan., to prepare coal from its No. 15 and No. 17 mines.

In 1936 a plant was erected by Mineral Products Co., a P & M affiliate, at West Mineral to recover pyrites from coal refuse. The recovery system

The company's operations straddle the mid-continent. A million-ton capacity strip mine is scheduled to be in production near Gallup, N. M., by January 1962

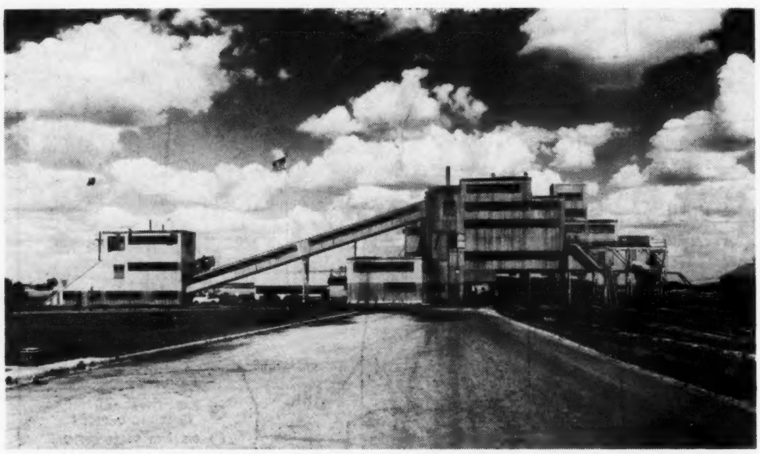
In 1915 the company opened its first strip mine, and in 1918 bought the first electric shovel ever used in the mining industry. Coal was still loaded by hand and mules provided the locomotion. At present all but one of P & M's operations are strip mines

was designed around a process patented by a son of C. F. Spencer, Kenneth A. Spencer, who organized and headed Mineral Products Co.

Plans Laid for Expansion

The father-son team—in 1940 K. A. Spencer was made general manager and treasurer of P & M—began to have visions of a chemical industry in the tri-state area of Kansas, Missouri and Oklahoma—using coal and other raw materials supplied by P & M, of course. In fact, a plan was drawn up outlining in detail a series of plants, showing how they could complement each other. It was supported by information on the labor supply, transportation facilities and the availability of natural resources.

With Europe deep in a War in which we were at the time morally, if not actively, involved, the Federal Government became vitally interested in the plan and decided to build the Jayhawk Ordnance Works near Pittsburg, Kan., a smokeless powder plant, near Pryor, Okla., and a shell-loading plant near Parsons, Kan. The Pittsburg & Midway Coal Mining Co. was selected to design, construct and operate the Jayhawk Ordnance Works. P & M pledged its entire assets as a performance bond and organized the Military Chemical Works, Inc., with C. F. Spencer as chairman of the board and Kenneth A. Spencer, president, to operate the Jayhawk plant.



In 1910 the P & M built its first coal washer at its Mine No. 10. Most of the coal now sold by the company is sold on a Btu basis and on long term contract. The modern preparation plant at Mine No. 19 produces 2700 tons of clean coal per shift from a raw feed of 4150 tons

Charles F. Spencer died December 1, 1942, at the age of 71, passing over the reins of the coal company to Kenneth A. Spencer. An older son, Harold A. Spencer, who had been operating his own coal company, the Pioneer Coal Co., was named vice president and treasurer. Pioneer, which previously had been operated as an affiliate company, was absorbed into the growing P & M complex in 1959.

At the end of World War II, Kenneth Spencer organized a company to lease, and later purchase the Jayhawk Works from the Government, and Spencer Chemical Co. was born. Named for Charles F. Spencer, the chemical company was to grow rapidly and become an important segment of American industry.

Meanwhile, the coal company was going ahead with its own expansion. In 1938 another "first" was made with the erection of a 33-yd shovel at Mine No. 15, near West Mineral. At the time it was the largest in the world.

Markets were changing and so was the coal industry. In 1885, the bulk of P & M's production was going into the domestic market. Then came the railroad market; and finally, in recent years, the utility market. P & M began to look at itself as a volume producer of an energy raw material. The long-term contract became both a sales and operating tool, and efficiency became a fetish.

With the War-induced demand for energy, P & M had its first million-ton year in 1943. In 1947 the company entered the Western Kentucky coal field with the opening of its Colonial mine near Madisonville. P & M's three Kentucky mines now produce 80 percent of the company's total production. Then in 1949 the Osage mine was started on the western slope of the Rocky Mountains near Steamboat Springs, Colo. This mine has the distinction of never being troubled by a shortage of railroad hopper cars—it ships in box cars.

Record Breaking Growth

From 1943 through 1959 the company was the fastest growing coal producer in the Nation, expanding at an average rate of 200,000 tons a year. In 1959 it was the 15th largest coal company in the U. S. It can also be pointed out that with the exception of the Pioneer acquisition in 1959, all of the increase was generated internally. No companies were absorbed—the sales department went out and sold more coal and the operating department increased production to meet demand.

CHARLES F. SPENCER

KENNETH A. SPENCER

HAROLD H. SPENCER

EDWIN R. PHELPS

Much of the success of P & M can be credited to the foresight and leadership of the Spencer family. Charles F., president from 1911 until his death in 1942, introduced the company to strip mining in 1915. Kenneth A., president from 1942 until his death in February 1960, sought new markets for P & M coal and brought to life a vision of a chemical industry in the tri-state area of Kansas, Missouri and Oklahoma. Harold H., chairman of the board since 1953, has been the "balance wheel" during a time that sales and production were being quadrupled.

As P & M enters its 76th year, the reins of the company have been handed to Edwin R. Phelps who was elected president in March 1960. Operating vice president for the past seven years, he has had great success in leading the battle to increase efficiency in the mining and preparation of coal. He typifies the aggressive alertness to opportunity that has been P & M's big stock in trade.

It is the utility market that has contributed the greatest to P & M's growth, and in 1959, 67 percent of production went into the market. Twenty-two percent was sold to general industrial consumers, and railroads and retail dealers accounted for 11 percent.

At the present time all but one of the company's mines are stripping operations. The exception is P & M's newest operation, the De Koven mine near Sturgis, Ky. It is an all a-c mine which produced 1,155,977 tons of the 4,142,076 tons mined by the company in 1959. Plans are underway to increase the productive capacity at De Koven to 2,400,000 tons annually.

Following the untimely death of K. A. Spencer on February 19, 1960, Edwin R. Phelps was named president. He had been operating vice president for the previous seven years. Harold Spencer, chairman of the board since 1953, continued in that capacity.

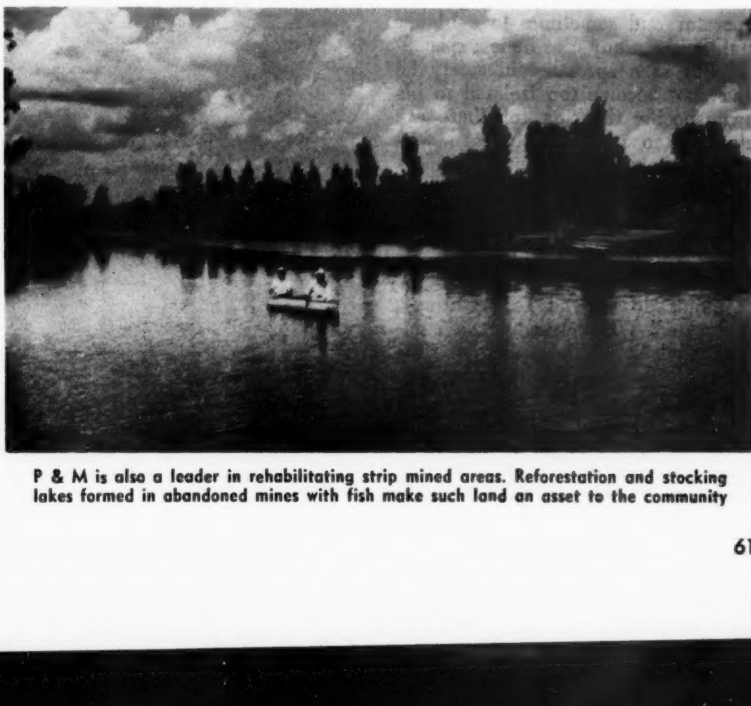
Pioneering in the West

P & M is continuing its tradition of aggressiveness under E. R. Phelps and in June of this year, it was announced that the company had signed a long term contract with the Arizona Public Service Co., Phoenix, Ariz., to supply coal for a new 110,000-kw steam electric generating station to be built near Joseph City, Ariz. It will be the first coal-fired utility power plant in the State of Arizona. Scheduled to be completed by late spring of 1962, the plant will burn 380,000 tons of coal annually and the agreement calls for the dedication of coal reserves for 35 years. P & M will open a 1,000,000 ton a year capacity strip mine just west of Gallup, N. M., to supply the coal. This will be the sixth state in which the coal company is operating.

The agreement with the Arizona Public Service Co. is the first major contract with a large scale coal burning power plant in the Southwest, but you can bet P & M expects others to follow.

It was also announced in June that Pittsburg & Midway Coal Mining Co. would merge with Spencer Chemical Co., the towering descendent of Military Chemical Works, Inc., a onetime P & M wholly owned subsidiary. According to reorganization plans P & M will be operated as a wholly owned subsidiary of the chemical company. This will have the effect of increasing the financial backing of the coal company and will undoubtedly lead to even greater expansion.

In this way P & M rounds out its 75th year of business—proud of its past and confident of its future.



P & M is also a leader in rehabilitating strip mined areas. Reforestation and stocking lakes formed in abandoned mines with fish make such land an asset to the community

By H. D. STOTT
Director of Industrial and Public Relations
Calumet Division
Calumet & Hecla, Inc.

Viewpoints on Safety

SCOPE of a safety program is directly related to the size of the company, and the responsibility for that program rests squarely with that group known as management staff.

In a small company a person may have to wear two hats, one as an operator and one as a staff man. This is a difficult position to occupy for it is not normal for a man to be able to be so objective that he may properly take each point of view. In a larger company with a line and staff type of organization, there is sometimes friction between the two groups because the "staff man" is more of an "operator" than the operator is himself. A good staff man should ever be alert to this tendency and do his utmost to serve as staff, although in the area of safety this is most difficult. The subject is so broad in its implications that many of the aspects become greater than performing a line job. The consequences have far-reaching effects.

Analyze Potential Hazards

There is the safety engineer; he is a staff man sometime reporting to the operator and sometimes to a higher staff level. In any case he is a specialist, but as a specialist in safety he must not become too isolated to his own specific thinking for there are already too many safety men who "follow their noses." However, there are safety departments and engineers who are really applying modern management principles.

The writer has had men on his staff say to him, "The operator shouldn't do so and so because it isn't safe." When asked for a complete analysis of the situation, they had not always used a sound approach. What is the probability of having an accident in relationship to the savings gained by a new method? What do our own records show? What can be done to make it a safe operation, and what will it cost? A staff man *must take that second look* and should not try to get off the hook by simply saying "it isn't safe."

Of course, a staff man has to be everlastingly curious. He has the time, or should have, to study every accident in its fullest detail. Many times the real cause of an accident is not discovered because staff and line men are all too willing to accept the obvious. There are instances of great reluctance to change.

Success in Safety Depends Upon Attitudes

The management staff should accept major responsibilities in employe education. In this day and age, the management man closest to the worker is recognized as the key man in any achievement and safety is one of his duties. He should teach the employe the techniques or mechanics of working safely as related to guards, apparel, barring down, proper machine set-ups, and so on.

The education a staff man can help with most is not the teaching of particular techniques, but rather teaching all men to behave as they do not always behave. "He knew better," even though an accident did occur. The person involved did not behave as he should have; nor did the foreman since he did not assign the man safely.

We must find the way to educate

First line foremen and all others directly concerned with production must learn to appreciate the effect accidents have on performance and the ultimate success of operations

Part V—Responsibility of the Management Staff

people to behave as they should and even though this is quite a job, it is nevertheless a responsibility of the staff. The author believes that success or failure in safety is caused by an attitude rather than by techniques or application of them.

Another responsibility is to keep abreast of changes, but it is preferable to keep ahead of them. Look at worker skills. In 1910, 18 percent of the working force was unskilled, but in 1950 only eight percent was unskilled. It is estimated that by the end of 1960 only about four percent will be unskilled. Just what has this change done to safety? A good staff man is analyzing this trend as it applies to his company, for it is certainly going to call for a better job of placement.

Workmen's Compensation

Labor relations people should not hamstring operators of tomorrow with poorly worked out seniority or transfer clauses which create safety headaches in the future. Some of this has been witnessed in the railroading business. Even though the mining industry has not had to face it as much as the manufacturing or railroading industries, one day it will.

Those of us charged with dealing directly with the union should work closely with all who are concerned with safety. Union leaders are becoming more and more vocal in this matter. Back in 1911, when Wisconsin passed the first Workmen's Compensation law, there was not much concern. By 1921 nearly all of the states had such a law, most of them patterned after the British Act of 1906, "the exclusive remedy for work injuries."

It was only recently that unions began to exercise any interest in Workmen's Compensation laws. Now they are at them with "hammer and tongs" and in many instances know more about the laws than management men. In the writer's state, Michigan, we have run into a tough one—"aggravation of a known condition." A solution to this has still not been established, but it points up the fact that it is costly to place a man on a job if it aggravates his condition. Safety? The question of placement in such a case is loaded with cause for concern. Everyone in staff should anticipate this new trend as it affects safety.

Union demands to equalize Workmen's Compensation to the amount paid under "sick benefits" are going to grow and can see-saw upward unless the staff men of management are alert to finding a solution. The union is taking the position that management should spend as much money and give as much attention to the care of the disabled as it does to plant maintenance.

The management man closest to the worker is the key man in any achievement. His duties include teaching employes the techniques or mechanics of working safely

Link in Safety Program is Supervisor

Staff men should be really aware of costs, in this case to safety costs. The author does not believe that in this respect supervisors have a very satisfactory understanding of their responsibility. In the July 1959 issue of *Mining Congress Journal*, Herbert R. Westlund, chief safety engineer,

Argonaut Insurance Co., provided an article, "The Cost of Mine Accidents," which every mine supervisor should read and study and then reread.

Too many uninformed and uneducated supervisors say "Insurance pays the bill." These people lose the perspective of the underlying principles of accident prevention, one of them being to improve efficiency and thereby reduce costs. It is up to staff men to get this idea across.

We have accepted the foreman-supervisor as the big link in any safety program. Today's supervisors have come a long way from yesterday's. How well will he be equipped to deal with the problems of tomorrow? The management staff has a real responsibility in finding the means for helping line operators cope with the many changes which are just ahead. Doubtless many of today's line operators are "doing the job" only because of state and Federal laws and civic and company rules. Many of these men do not have the mental attitude or capacity to understand what might be the real contributory factors to a poor safety record.

Our responsibility in staff positions is to help those who can be helped, and to provide the greatest possible assistance in selection of the best qualified man for positions of supervisory responsibility.

Politics and Safety

Politics unfortunately enters into safety. For example, a general liberalization of compensation laws has become a favorite point of debate and action in many legislative bodies. This is where the management staff comes in. Every member of this group must be on the alert for bills which may have a negative effect, although meant to do a good job, in areas of safety and rehabilitation of the injured. Not only must management staff be alert enough to recognize such situations, but it must call them to the attention of operating personnel, pointing out the possible reactions as well as the inevitable results of new and restrictive compensations laws. Insurance companies, in the main, have taken little action against some of the past proposed changes in such laws. They have merely tended to increase their rate schedules which makes employers the eventual bearers of costs created by laws of this nature.

A great responsibility of staff men is to bring to the knowledge of operating personnel the real impact of safety costs. Statements have been made that the ratio of direct to indirect costs is four to one. This formula, devised in 1926, does not take into account changes in fringe benefit labor costs since then, and therefore it is the writer's opinion that the four to one ratio is extremely conservative. Operating supervisors must not take the position of "Oh, well, insurance pays the bill." Staff is doing a poor job if this happens.

Safety Achievements Should Be Publicized

First line foremen and all others directly concerned with production must learn to appreciate the effect that accidents have on their performance and the ultimate success of operations. When supervisors really understand the close relationship between the prevention of accidents and an efficient operations, we will have a great safety record—built on value and not fear.

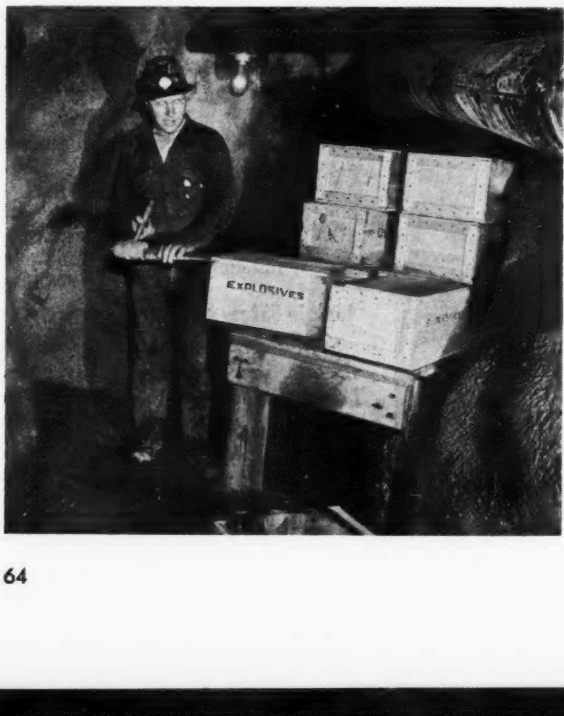
In the field of public relations, the staff man's responsibility is to deal effectively with all sorts of news dispersers; radio, television, newspapers and local community personnel. Let one man be hurt in a mine or mill and it becomes an exaggerated story. Just review these headlines: "Explosive Fire, Cave-in Kills Four U. P. Miners. Thirty-five men are taken from 'Belching Hell.' " And yet little mention was made of an equal number of people killed in one automobile accident. This particular story was printed in papers all over the land. News stories such as this provide the industry with a poor name for safety, and it would therefore be beneficial for staff men to get out more stories of how safe their operations are; in other words, get out the positive side as well as allow the negative side to be published. For instance, there is probably a worthwhile safety story that could be told about several Lake Superior district mines which were worked for a total of 881,291 hours without an accident —there are not many industrial plants able to boast such a record.

Intangible Profits from Good Safety

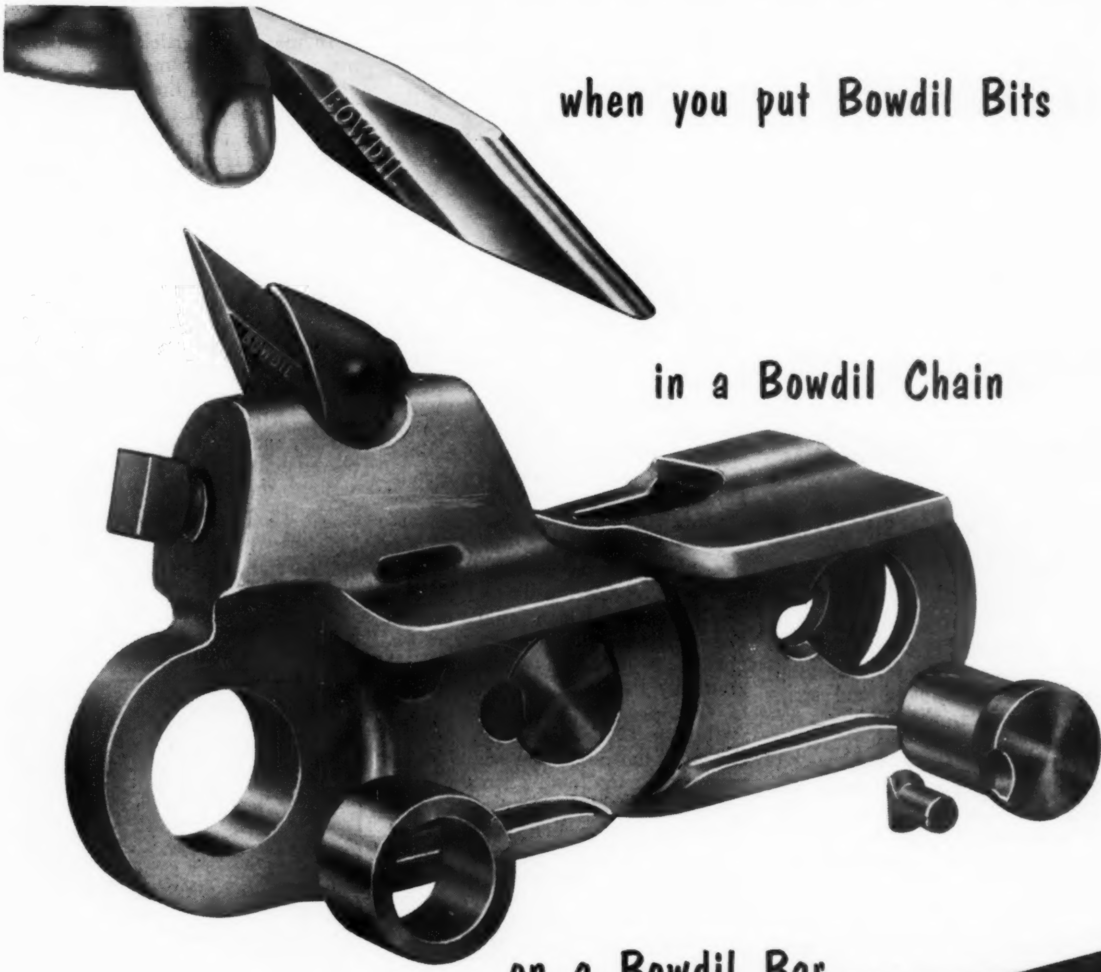
Safety should not be looked upon as welfare work, but should be regarded as a very real part of the over-all responsibility for profitably running a company. Many top management men have "arrived" because they are doers—they get things done —and this is as it should be. We are fast approaching a change and a need for an adjustment to it. The change in worker skills, which was pointed out, is only one facet that needs attention. Add this to the many new and growing challenges facing management men, and the need for better understanding in the interrelationships of people becomes apparent.

The author's challenge to top management is this: be aware of changing conditions and strive to create an understanding between line and staff that all are working for the same cause—the betterment of those they serve. In good safety results there are better profits, not only in dollars and cents, but also in that intangible profit which comes from adequate and decent treatment of people. In the long run, the quality and amount of our successes depends upon the human element.

Accidents are not a necessary part of mining, but safety is.



Safety should not be regarded as welfare work but part of the over-all responsibility for profitably running a company



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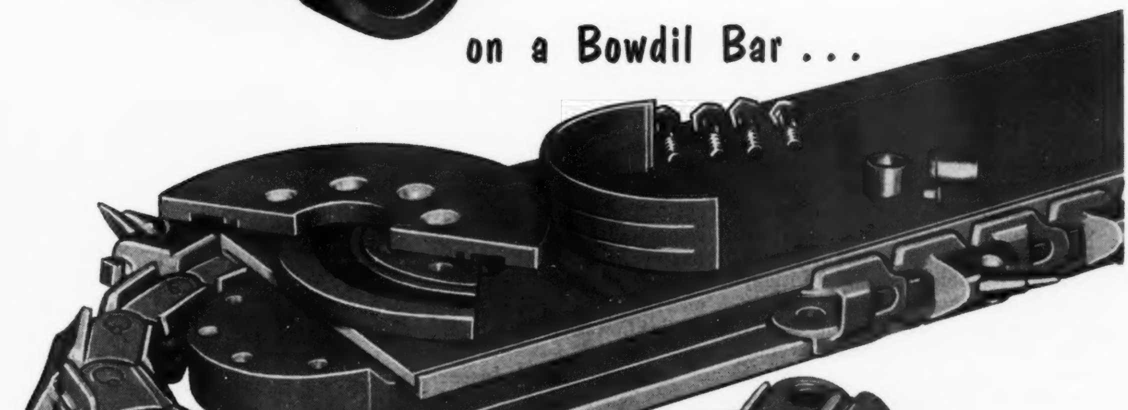

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Operators' Corner

Reducing Maintenance Cost Through Inspection

By D. P. WALSH
Central Region Manager
Magnaflux Corp.

Because of increasing capital investment in mechanization for increased efficiency in underground and strip mining operations, the problems of repair and downtime are receiving more attention. Here are two nondestructive testing methods which remove doubt when decisions are to be made to salvage, repair, or replace parts during repair or overhaul operations

TODAY, as heretofore, a thorough, prying, visual examination plays a prominent part in influencing our decisions. Yet, years ago, it was discovered that we should not always believe what we see. For example, visual observation could not reliably locate small, tight-lipped defects in metal parts, and failures could occur very shortly after repair or overhaul. For this reason, aids to vision such as magnification, "oil and whiting," local heating and pressure were employed to help locate such defects. This discussion will consider more modern methods which are used extensively to improve "seeability" and provide positive information for decision making.

In most maintenance programs there are certain objectives. Some of these are:

(1) Prevent downtime or lost production.
(2) Detect and correct any defective part which might cause damage to other parts and more extensive repairs.
(3) Be assured that repair or overhaul is adequate and that the equipment's performance will be predictable—that is, essentially "as good as new."
(4) Hold overhaul costs to an absolute minimum.

These objectives suggest a program that will time maintenance to satisfy operating conditions, yet be sufficiently frequent (but not more so) to prevent unplanned shutdown. They also suggest *action* based on experience, records, or manufacturer's recommendations. Finally, thorough inspection during overhaul or maintenance will assure satisfactory repair, and will prevent use of bad parts and the throwing away of good ones.

At this point, let us briefly consider how a breakdown occurs. Insurance company reports tell us that a large percentage are due to fatigue cracks. For example, a small fatigue crack begins its growth at the top of a shaft. It gradually grows larger in service. Due to flexing, a second fatigue crack starts from the bottom. Both grow in size until the remaining sound metal cannot bear the load. Then the shaft breaks suddenly. These cracks could have been located at any stage of their growth, thus avoiding the cost of a breakdown and more extensive repairs.

Fatigue cracks generally occur at a highly stressed area and grow in length at right angles to the principal stress. They initiate in this area, usually due to stress raisers such as punch marks; or blemishes, such as inclusions, dents, rough surfaces; or poor design, such as sharp fillets, keyways, and the like. Though manufacturers use stress analysis extensively to develop designs with improved fatigue resistance, the fact is, that only so much "mileage" can be built into a piece of equipment and still "maintain a price that people can afford to pay."

Magnetic Particle Inspection—Reliable and Economical

The first inspection method to be considered is called "magnetic particle inspection." It applies to all magnetic materials and is the most economical of all test methods for reliably detecting fatigue cracks at any stage of growth. In principle it can be likened to a horseshoe magnet with north and south poles which hold a keeper magnetically. Bend the magnet so that north and south poles touch, and it will not hold the keeper, but it will hold iron filings.

In magnetic particle inspection, a magnetic field is made to cross a crack. One side of the crack is a north pole and the other is a south pole. These poles attract and hold finely divided magnetic particles, even though the crack is contaminated or filled with dirt. When the part is being magnetized, particles in the form of red, gray or black powder are applied. These instantly mark a crack right on the part itself.

Figure 1 shows a dry powder indication of a crack in a weld. On this structure 15 percent of its 315 welded clusters had such fatigue cracks. Magnetic particle inspection located the cracks, indicated that they were removed completely prior to repair, and assured the integrity of the repair welds. In this manner, the structure was put back in excellent condition. Many years of useful life were added and a probable failure was averted.

While dry magnetic particles are used extensively on rough, dry surfaces such as welds and castings, particles suspended in an oil distillate are used almost exclusively on "working" parts which are apt to have an oil film. These particles, as used in maintenance, are coated with a dye which fluoresces brilliantly under near ultra-violet (3650 Angstrom units) black light. Thus, even the smallest fatigue crack gives off a light which attracts attention.

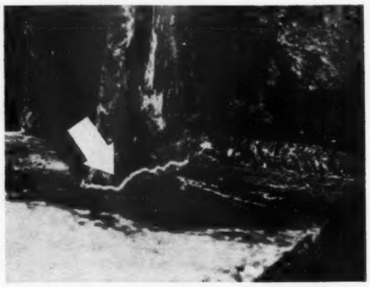


Fig. 1. Magnetic powder pattern marks a crack in a weld

Fig. 2. Fluorescent magnetic particles "light up" fatigue cracks at the root of gear teeth

Figure 2 illustrates a gear with a typical fatigue crack pattern. The

cracks are lighted up by fluorescent* magnetic particles. Where this condition exists on large gears as in strip mining equipment, where replacement could not be immediate, the service life has been extended by reversing the gear thus changing the direction of loading. On gears which have only one keyway, fatigue cracks have initiated at the keyway on the inside diameter and extended outward towards the root of the tooth. This could indicate poor design and extremely high stress concentration at the corner of the keyway.

Magnetic particle inspection is being used by several mining companies on a large variety of parts. Typical of these are crank discs, swivel arms, bull and trunnion gears, gear trains, sprockets, shafts, axles, dipper teeth, steering gear, and engine parts. Typical of the latter is the crankshaft removed from earth moving equipment that is illustrated in figure 3. The fatigue cracks shown by fluorescent

Fig. 3. Typical fatigue cracks on crankshaft are indicated by fluorescent magnetic particles

magnetic particles would have caused failure. Replacing the shaft prevented this. With large diameter shafts, where a replacement part is not readily available, the growth of fatigue cracks can be slowed down by drilling small holes at the extreme ends of cracks. Such holes must be at the extreme ends and partially in sound metal beyond the crack end.

Inspecting Non-Magnetic Metals and Materials

The second method to be discussed is "fluorescent penetrant inspection."

** This method should not be confused with fluorescent penetrant inspection.*

While it can be used on any metal or solid body, it is recommended specifically for non-magnetic metals and materials for the following reasons: (1) parts must be cleaned thoroughly so that cracks are clean and open, (2) a little more processing time is involved, and (3) expendable materials are somewhat more costly. These points also apply to visible penetrants which show cracks as red lines or dots on a white background. Fluorescent penetrant inspection produces vivid indications which fluoresce brilliantly under near ultra-violet (black) light. Thus, cracks are marked right on the part itself.

The application of penetrant methods are relatively simple. After cleaning, penetrant is applied to the surface of parts and is drawn into cracks or pores by capillary action. After a few minutes, the penetrant is removed from the surface by water wash or with a recommended cleaner. After cleaning, penetrant still remains in the cracks or pores. A wet or dry developer is then applied. It acts like blotting paper and pulls the penetrant back to the surface within a minute or two. The part is then inspected under black light.

After being treated with fluorescent

Fig. 4. Fatigue crack in bronze gear is located by fluorescent penetrant inspection using "black" light

penetrant materials, the bronze gear illustrated in figure 4 is being checked under black light. In color photography, or as actually seen, the fatigue crack fluoresces a vivid yellow which attracts attention. This color is the easiest to see by human vision and the contrast is perhaps 100 times that of red on a white background. Thus, even minute cracks are hard to miss. In the mining industry, bronze gears, pump impellers, and sprockets, aluminum and magnesium parts, carbide tipped tools, or other non-magnetic materials can be inspected by this method.

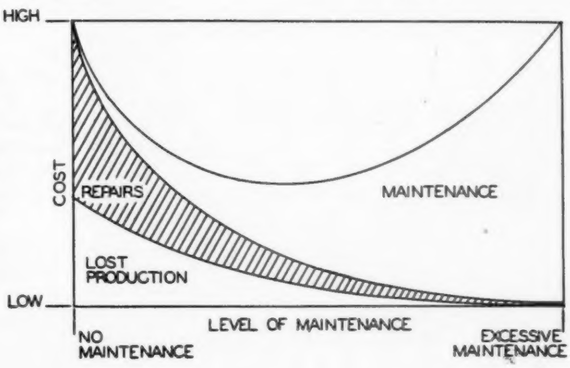
Fluorescent penetrant materials are also used for leak detection. Penetrants of various hues and fluorescent additives are also available for water or oils. For leaks in empty tanks or similar containers, penetrant is applied on one side only and the other side is examined under black light. Very small leaks can thus be detected within a few minutes. As most oils have natural, though relatively low fluorescence, the 100-watt high intensity black light can be used to locate such leaks in oil filled housings such as pumps, transmissions and crankcases.

Even with the best inspection procedures, maintenance can be underdone or overdone (see figure 5). There may be little maintenance but instead there are repairs plus failures which magnify production losses. There may be a lot of maintenance at extremely high cost but no repairs or failures. The best point of economic return lies somewhere between these extremes, but it will vary depending on the particular operation. The overall cost will be lowest when the cost of maintenance approximates the cost of repairs plus the cost of production losses.

The methods discussed have found wide usage for many years in automotive overhaul, and in railroad and aircraft, plant, and to a lesser degree,

(Continued on page 74)

Fig. 5. Over-all cost related to the level of maintenance. The best point of economic return lies somewhere between the two extremes of no maintenance and excessive maintenance, but it will vary depending on the particular operation



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For your mining operation, there are many reasons why Whyte Strand is the best wire rope you can use on your shovels. Here are just a few:

- Every foot of Whyte Strand is made by Macwhyte from domestic steels drawn and fabricated in Macwhyte's own wire and rope mills
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- Special Macwhyte lubricants are used in accordance with the needs of the equipment or the type of service in which the rope will be used.
- Entire wire and rope mill operations are concentrated on the making of one product . . . *wire rope!*

But the proof of the pudding is in the using — and here's where Whyte Strand shines. You can spend all kinds of money, but you can't buy a better rope for your shovels than Whyte Strand . . . nor one that will give better service, with less trouble.

Whyte Strand shovel ropes are made in two strengths — Monarch Whyte Strand Improved Plow Steel and PREmium Whyte Strand Extra Improved Plow Steel — both are listed in bulletin No. 6025.

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As Viewed by HENRY I. DWORSHAK of the American Mining Congress

While the current session of Congress is generally expected to last not longer than Labor Day, much in the way of legislative fireworks is definitely on the agenda.

Senator Kennedy of Massachusetts, the Democratic nominee for President, presumably will use his influence as leader of his party in behalf of pending legislation to legalize picketing and secondary boycotts at construction sites, to increase the minimum wage and broaden coverage of the Wage-Hour Act, to establish a medical aid program for the aged as part of the social security system, and to provide Federal subsidies for education. These measures are generally endorsed by the Democratic platform.

On the other hand, the outnumbered Republicans in Congress, under the leadership of Vice President Nixon as their party's nominee for President, will battle just as hard as their opponents to make a record which they think will appeal to the Nation's voters November 8—with the threat of Presidential vetoes of Democratic legislation tending to even somewhat the balance of power. The outcome remains to be seen.

★ ★ ★ ★ ★ ★

Washington Highlights

CONGRESS: Legislative fireworks assured

PARTY PLATFORMS: Minerals, fuels get attention

TARIFF COMMISSION: Holds peril-point hearings

ESCAPE CLAUSE: Government loses court case

COAL RESEARCH: Action promised on new program

WILDERNESS: Senator Murray sponsors revised measure

NATIONAL FORESTS: Magnuson bill would limit access

LEAD-ZINC: Subsidy amendments to be offered

POWER SITES: Court upholds mining claimholder

★ ★ ★ ★ ★ ★

PARTY PLATFORMS CALL FOR MINERALS, FUELS PLANNING

The 1960 platforms of both major political parties call for long-range planning and increased research with respect to the Nation's mineral resources, including fuels.

Democratic pledges include support of "continued study and research on energy fuel resources" and "the establishment of a national fuels policy." Also pledged are "immediate efforts toward the establishment of a realistic long-range minerals policy."

The natural resources plank of the Republican platform pledges that party to pursue a policy of long-range planning and programming on minerals and fuels, including increased research on coal. "Our objective is for further growth, greater strength, and increased utilization in each great area of resource use and development," the plank states.

Pending in both Houses of Congress is legislation which would establish a bipartisan Senate-House Committee charged with conducting a comprehensive study of the Nation's fuel resources, with a view toward the establishment of a national fuels policy. This legislation, which has the strong endorsement of the coal mining industry, might now receive further attention before Congress adjourns.

TARIFF COMMISSION HOLDS PERIL-POINT HEARINGS

The Tariff Commission is in the midst of extensive hearings begun last month as part of its peril-point study with respect to the 2,500-plus articles upon which concessions may be offered by the United States during negotiations in Geneva, Switzerland, scheduled to get under way in September.

These negotiations, aimed at a progressive reduction of international restrictions on trade, will be participated in by the 37 nations signatory to the General Agreement on Tariffs and Trade (GATT).

Under the Trade Agreements Act, the Tariff Commission is required to make an investigation and to report to the President its findings with respect to each article upon which import duties may be lowered or other import restrictions relaxed. Commission findings must specify (1) the limit to which duty reduction or other concession may be granted or extended without causing or threatening serious injury to the domestic industry producing like or directly competitive articles, and (2) if increases in duties or additional import restrictions are required to avoid serious injury to the domestic industry, the minimum increases in duties or additional import restrictions required.

Representatives of the chemical industry, initial witnesses at the peril-point hearings, generally opposed the granting of further concessions on a wide range of chemical products. The list of articles contains a variety of semimanufactured and manufactured metal products; spokesmen for domestic manufacturers of like articles are scheduled to testify late this month.

GOVERNMENT LOSES APPEAL IN ESCAPE-CLAUSE CASE

The U. S. Court of Customs and Patent Appeals has affirmed a Customs Court decision in which it was held that the President, under the escape-clause provision of the 1951 Trade Agreements Extension Act, has no authority to proclaim a rate of duty different from that recommended by the Tariff Commission.

The case in question involved the importation of bicycles. The importer protested the increased rate of duty assessed under a Presidential Proclamation issued pursuant to an escape-clause proceeding. The increased rate so proclaimed was lower than the rate recommended by the Tariff Commission, and the importer contended, among other things, that the President's power was limited to approving or disproving the Commission's recommendation and that he was not authorized to modify or to adopt only partially the action so recommended. The Customs Court found in his favor, and the Government appealed.

Language of the pertinent statute was cited by the appeals court as follows: "The President may make such adjustments in rate of duty * * * as are found and reported by the Commission to be necessary to prevent or remedy serious injury." The court then reasoned that the President had the option of proclaiming a recommended adjustment in the rate of duty or disregarding the Commission's recommendation and making no changes in existing rates. If the situation were otherwise, the court indicated, the procedures set up in the escape-clause would be meaningless.

This decision may have implications with respect to other escape-clause actions taken by the President, including his imposition of quotas on lead and zinc in 1958. As a result, it is generally expected that the Government will carry the bicycle case to the Supreme Court.

QUICK ACTION PROMISED ON COAL RESEARCH OFFICE

Secretary of the Interior Fred A. Seaton has announced that the Interior Department will proceed as quickly as possible to establish an Office of Coal Research to contract for research aimed at increasing the utilization and output of coal. The Act authorizing the program was signed into law July 7 by President Eisenhower.

The new law provides that the Office of Coal Research will be aided by advisory groups in the screening and selection of coal research projects. These advisory committees, the Secretary said, will be selected to give broad representation from all segments of the coal industry.

REVISED WILDERNESS BILL INTRODUCED IN SENATE

Chairman Murray (Dem., Mont.) of the Senate Interior Committee has introduced a revised bill to establish a National Wilderness Preservation System which, as provided in earlier Wilderness bills, would be composed in part of millions of acres of national forest areas now open to prospecting and mining under the general mining laws.

The new measure retains the ban on any form of commercial enterprise within the Wilderness System. It also retains language providing that prospecting and mining, and exploration for and production of oil and gas, would be permitted only in exceptional circumstances as determined by the President and under such regulations as he may deem desirable.

Although mining and other natural-resource industries are strongly opposed to such legislation—on the basis that it would hamper economic development of the West—it received a boost at the recent Democratic Convention in Los Angeles. A plank in the 1960 platform of that party states that "A National Wilderness System should be created for areas already set aside as wildernesses. The system should be extended but only after careful consideration by the Congress of the value of areas for competing uses."

BILL WOULD LIMIT FOREST ACCESS RIGHTS

A bill which would greatly broaden the Forest Service's control of access across national forest lands to adjacent or intermingled private lands has been introduced by Senator Magnuson (Dem., Wash.). The measure was referred to the Senate Public Works Committee, a special subcommittee of which may hold public hearings on it this Fall.

Mining claim owners and other persons owning lands within the boundaries of national forests now have a statutory right of ingress and egress and the right to build roads across the national forests to enable them to get to and from, and to utilize, their property. The Forest Service testified earlier this year that it believes it should have reciprocal rights across the applicant's land "in any situation where mutual needs exist" even though it could attain its ends by exercising the right of eminent domain.

Magnuson's bill would authorize the Secretary of Agriculture, with respect to lands administered by the Forest Service, (1) to require payment of fees for use and maintenance of roads and trails; (2) to grant easements for rights of way for roads "upon such terms and conditions as he may deem are in the public interest"; and (3) to condition the grant of any right of way or permission to cross Forest Service lands upon the granting to the United States of rights or permission to cross the applicant's lands.

ALLOTT WILL PROPOSE LEAD-ZINC AMENDMENTS

Senator Allott (Rep., Colo.) has served notice upon the Senate that he will propose several amendments to the House-passed Edmondson lead-zinc subsidy bill when it reaches the Senate floor. This measure was approved without change by the Senate Interior Committee and is now on the Senate calendar.

The Allott amendments would (1) make the program applicable to all producers rather than limiting it to small producers; (2) reduce the payment targets from 17 cents per pound for lead and 14½ cents per pound for zinc to 15½ cents and 13½ cents respectively; (3) reduce the annual maximum production upon which subsidy payments could be made to 2,000 tons of combined lead and/or zinc (the bill's ceiling is 2,000 tons of each); (4) finance the program by authorizing the Secretary of the Interior to borrow up to $50 million from the Treasury rather than by direct Congressional appropriations; and (5) set up a schedule of subsidy payments ranging from 0.2 cents to 3 cents per pound on lead and from 0.15 cents to 1.95 cents per pound on zinc.

Under the Edmondson bill, subsidy payments would give producers the equivalent to what they would have received at lead and zinc prices of 17 cents and 14½ cents per pound, respectively.

Also pending in the Senate is a House-passed tax bill to which the Senate Finance Committee added a lead-zinc import tax amendment sponsored by Senator Kerr (Dem., Okla.). This amendment would replace present tariff duties on the two metals and their ores and concentrates with higher import taxes, a portion of which would be suspended whenever the prices of lead and zinc are at or above 14½ cents for lead and 13½ cents for zinc on a quarterly basis.

(Continued on page 84)

personals

Wallace Macgregor has been appointed president of Climax Molybdenum Co. and elected vice president of American Metal Climax, Inc., the parent company. He succeeds **Frank Coolbaugh,** president of American Metal Climax, who has also been serving as president of Climax Molybdenum since June 1, 1959.

W. Macgregor

A former treasurer of Climax and controller of American Metal Climax, Macgregor has been a vice president of Homestake Mining Co. since his departure from American Metal Climax in January 1958.

R. Henderson

The company has also announced that **Robert Henderson** has been appointed vice president of Western operations. He will be responsible for production of molybdenum and tungsten from the company's mine and concentrator at Climax, Colo., and production of uranium and vanadium in Colorado, Utah, New Mexico, Arizona, and Texas. Prior to his appointment, Henderson was general manager of Western operations of Climax, and before joining the company in 1936, he was associated with International Nickel Co. and other mining enterprises.

Cleon R. Fowler recently became general manager of mines, Pocahontas Fuel Co. Division of Consolidation Coal Co. Prior to the new appointment, he had been general superintendent of Arkwright No. 1, Osage No. 3 and Pursglove No. 15 mines of Christopher Coal Co., another Consol subsidiary. Fowler has been associated with the Consol organization since 1940 when he joined Christopher in its engineering department.

Ira E. McKeever has been appointed general manager of sulphur operations of Texas Gulf Sulphur Co. He will have direct charge of the company's mines and plants at all locations in the Gulf Coast region. McKeever joined Texas Gulf in 1952 as a member of the Exploration Department. He became assistant manager of mining exploration of Texas Gulf in 1958 while serving as vice president of Texas Latin Exploration Co., a subsidiary. For the past year he has performed company assignments both in the United States and Australia.

Walter A. Morris, vice president of Dawson Coal Co. and Dawson Coal Sales Co., has succeeded **Joseph H. Schneider** as president of the two companies. Schneider has become chairman of the board of directors.

Paul M. Kavanagh, formerly general manager of the Yukon Consolidated Gold Corp., Ltd., has been appointed chief geologist—exploration for Kerr-Addison Gold Mines, Ltd.

George O. Tarleton, president of Pittsburgh Coal Co. Division of Consolidation Coal Co. recently succeeded **G. A. Shoemaker** as president of the Western Pennsylvania Coal Operators Association. Shoemaker, president of Consolidation, had served as president of WPCA for more than nine years.

G. O. Tarleton

G. La Monte Weissenburger has been named president of Vanadium Corporation of America succeeding **William C. Keely** who was named chairman of the board. Weissenburger had previously been vice president.

W. E. R. Smith has been elected vice president of American Zinc Company of Illinois, an American Zinc, Lead and Smelting Co. subsidiary. He will continue to serve as resident manager of the company's operations at Dumas, Texas, a post he has held since 1955.

R. E. Kendall was recently appointed to the newly-created position of engineering manager at the United States Borax & Chemical Corp. Kendall joined the company in 1954 as a planning engineer to make a feasibility study for proposed open-pit mining at Boron, Calif. In 1956, when open-pit stripping started at Boron, he was named assistant mine superintendent, a position he held until his recent promotion. Before joining U. S. Borax, Kendall had been employed by Dayton Consolidated Mines Co.; Resurrection Mining Co., and Isbell Construction Co.

R. E. Kendall

Charles Lester Friedmann has joined United States Borax as a senior process engineer at the company's Boron operations. Friedmann formerly was associated with Titanium Metals Corporation of America at Henderson, Nev., as a production supervisor.

Richard J. Menze recently joined International Minerals & Chemical Corp. as assistant production manager of all Consolidated Feldspar Department plants and quarries in the United States and Canada. Menze was previously with Magnet Cove Barium Co., and earlier had worked for Tennessee Copper Co.

Charles W. Gilmore has succeeded **F. D. Woodworth** as mine industrial engineer for the New York Iron Ore Division, Jones & Laughlin Steel Corp. at Star Lake, N. Y. Woodworth has resigned.

Frederick W. Pfau has been named manager of International Salt Company's Detroit, Mich., rock salt mine, succeeding **John L. Ryon, Jr.,** who was named assistant director of production for the company. Pfau joined International Salt in 1930 as foreman of surface operation maintenance at the Detroit mine and held several other maintenance supervisory positions until 1959 when he became general superintendent of the mine. Ryon, who had been manager of the Detroit mine since 1959, will assist in co-ordinating and directing production activities of the company's four rock salt mines and three evaporated salt refineries located throughout the country.

Paul L. Alspaugh has been appointed a vice president of Union Carbide Olefins Co., division of Union Carbide Corp. Alspaugh has been manager-planning for Union Carbide Metals Co., since the early part of this year. Before that he was product manager-titanium for the Metals Company for two years. He joined the corporation in 1928 as an engineer for the Union Carbide Chemicals Co. During the early 1950's he was instrumental in the development of the remotely controlled continuous mining machine.

Douglas W. Middleton has been named development engineer of mining at the Cedar City, Utah, properties of Columbia Iron Mining Co., a U. S. Steel Corp. affiliate. He has been with the company since 1953.

Harold Powers has been named successor to **Ray L. Schultze** as general superintendent of Rio de Oro Uranium Mines, Inc. Prior to his appointment Powers had been chief geological engineer, and before joining Rio de Oro in 1957 he was State geologist with the Idaho Bureau of Mines. Schultze recently resigned from the company to become vice president and general manager of See Tee Mining Corp.

John R. Englehorn, manager of the Metal and Ore Department, American Zinc, Lead and Smelting Co., has resigned. **E. K. Minear,** purchasing agent and assistant to the vice president-traffic, will assume additional duties as director of purchases in the Metal and Ore Department, while **B. J. Bowden** has been appointed assistant director of purchases for ore. Bowden will be responsible for administration of the Metal and Ore Department.

Stanley H. Cohlmeyer will direct design and construction work for the Atlantic City (Wyo.) project of Columbia Geneva Steel Division, U. S. Steel Corp. Cohlmeyer has been manager of the corporation since 1957. Before joining U. S. Steel he was project engineer and chief estimator for Western-Knapp Engineering Co.

Officers for the recently reorganized operating organization of Pickands Mather & Co., which has changed from a partnership to a corporation, include **John Sherwin,** president; **H. C. Jackson,** executive vice president; and **H. P. Junod, W. H. Prescott, Jr., S. S. Robinson** and **E. C. Brunner,** vice presidents. Directors of the new corporation include **Charles S. Arms,** manager of the mining department; **Keith S. Benson,** chief counsel; **Robert S. Carey,** manager of iron ore and ferroalloy sales; **George S. Lockwood, Jr.,** manager of the coal department, and **Walter J. Williams,** manager of construction and development; all of Cleveland. **Everett L. Joppa,** general manager, and **Donald M. Chisholm,** associate general manager, both of the Lake Superior Mining Division and **John H. Bemis,** manager of the pig iron and coal department, Chicago, also became directors as did the four new vice presidents.

Robert F. Anderson recently became manager of domestic sales for the M. A. Hanna Co. He will be in charge of all iron ore and nickel sales activity for the company in the U. S. and Canada.

Roy Coulson, superintendent, Vitro Minerals Corp. at Riverton, Wyo., has been elected president of the Wyoming Mining Association. He succeeds **Myron L. Sisson,** Superintendent, Sunrise mine, Colorado Fuel & Iron Corp. Other newly elected officers of the organization include **C. J. Paustian** of Wyo-Ben Products Co., who becomes vice president, and **H. E. Potter** of Monolith Portland Midwest Cement Co. who was named secretary-treasurer.

Cecil K. Scott and **Donald F. Virant** have been named assistant superintendents at Mahoning mine and Embarrass mine, respectively, Pickands Mather & Co. Scott was previously operating assistant at the company's Bennett mine on the Mesabi iron range, while Virant held a similar post at Hilton mine at Shawville, Que.

Allen T. Cole, minerals consultant, has been appointed property manager for the Florida and Tennessee phosphate operations of International Minerals & Chemical Corp. He will be in charge of acquisition of land reserves, utilization of properties prior to mining, and reclamation of mined-out areas. Assisting Cole will be **W. A. Stringfellow,** reserves development engineer; **A. J. Hahn,** land reclamation engineer; and **Cecil Stange,** property superintendent. **J. R. Hall** will head the reserves acquisition program in the Tennessee field.

OBITUARIES

Albert L. Ferris, 71, retired mining engineer and geologist, died in Tucson, Ariz., April 26.

Mr. Ferris' career in the mining industry began in 1911 when he joined Shannon Copper Co., at Metcalf, Ariz. During World War I he served in the U. S. Army, after which he resumed engineering and geological work with Shannon. In the early 1920's he was employed by Phelps Dodge Corp. at Sonora, Mexico, and Morenci, Ariz. He was chief engineer at the Ojuela Unit of Cia Minera de Penoles in Mexico from 1926 to 1929. In 1936 Mr. Ferris went to Colombia, South America. There he held various engineering and managerial positions with several mining companies until 1946 when he returned to the U. S. to conduct mine examinations and retire.

Wilbur R. Joy, founder of Joy Coal Bit Co. of Prestonburg, Ky., and one of the developers of the Joy Coal Loader, died June 21 in Louisville, Ky. Mr. Joy and three brothers invented and developed coal mining and loading machines and formed the Joy Machine Co., early predecessor to Joy Manufacturing Co.

William Oscar McKamey, 74, retired vice president and a director of Sanford-Day Iron Works, Inc., died in Knoxville, Tenn., on June 4.

Robert E. Brott, 37, tramway foreman at the Nye, Mont., operations of American Chrome Co., died on June 6. Mr. Brott, a self-trained electronics enthusiast, was greatly responsible for improvements and efficient operation of his company's automated aerial tramway.

Ira L. Wright, 76, vice president and general manager of Black Hawk Consolidated Mines Co., died in Silver City, N. M., on June 17.

Thorald Farrar Field, 76, internationally known mining engineer and raw materials advisor to the Atomic Energy Commission died on June 13, in Duluth, Minn.

Carl H. Corbin, 59, former prominent eastern Kentucky mining engineer died in Elkins, Ky., June 25. He had been in semi-retirement because of ill health.

Manfred Bowditch, 69, director of health and safety for the Lead Industries Association died in New York City July 1. He had been associated with the organization since 1943.

NEWS and views

Eastern

Cleveland-Cliffs to Expand Republic Mine

The Cleveland-Cliffs Iron Co. has announced plans for a 900,000 annual ton expansion of the production of high grade pellets from low grade iron ore at the Republic mine, Republic, Mich. The facilities at the Republic mine and the concentrating and pelletizing plants are properties of Marquette Iron Mining Co., operated by Cleveland-Cliffs and owned by Cliffs, Jones & Laughlin Steel Corp., International Harvester Co., and Wheeling Steel Corp.

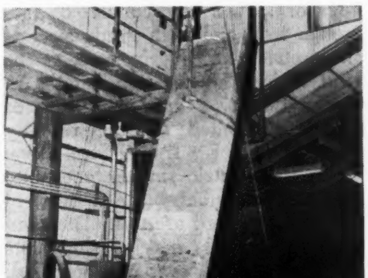
Capacity of the Republic plant will be boosted from the present 700,000 tons of iron ore concentrate to 1,600,000 tons per year. Half of the product will average 64½ percent iron content and will be processed into pellets through the new facilities at the Republic plant. The balance will be 62 percent iron in content and will be pelletized by the existing Eagle Mills pelletizing plant.

Six Winners of Sentinels of Safety Trophies

Six mines and quarries in Michigan, Minnesota, New York, and Pennsylvania have taken top honors in the 35th National Safety Competition sponsored by the U. S. Bureau of Mines. The winners, achieving the best safety records in their respective groups during 1959, were selected from 672 competing mineral operations—the second largest in contest history. For the first time since 1952, all winners were free of disabling injuries. Also, mines and quarries participating in this event reduced the injury-frequency rate to a new low—18.29 disabling work injuries for every million man-hours of exposure.

On the basis of records submitted to the Bureau, the winners are: quarries—Port Inland quarry, Inland Lime & Stone Co., Division of Inland Steel Co., Gulliver, Mich.; metal mines—Wauseca mine, Hanna Mining Co. (The M. A. Hanna Co.), Iron River, Mich.; open pit mines—Rouchleau mine, Oliver Iron Mining Division, U. S. Steel Corp., Virginia, Minn.; nonmetallic mines (underground)—Akron mine, Bestwall Gypsum Co., Akron, N. Y.; anthracite mines (underground)—Stockton mine, Jeddo-Highland Coal Co., Stockton, Pa.; bituminous coal mines (underground)—Harwick mine, Duquesne Light Co., Harwick, Pa.

American Zinc, Lead & Smelting Co. began casting 18,000-lb zinc alloy ingots in late June at its Monsanto, Ill., electrolytic plant. The



ingots, measuring 15 ft in length, 41 in. in width, and 10 in. in depth, are believed to be the largest ever to be cast for rolling purposes. After casting, the ingot is cropped and sawed to make two 80-in.-long rolling mill slabs, each weighing four tons.

Merger Planned by Flintkote and Diamond Portland Cement

Directors of the Flintkote Co., New York City, and of the Diamond Portland Cement Co., Middle Branch, Ohio, have approved a plan of merger through an exchange of stock. The proposed merger is subject to the approval of stockholders of both companies.

Diamond, an old-line mid-western cement producer established in 1892, completed an expansion program in 1958 that boosted rated annual capacity of its two operating plants at Middle Branch to 3,000,000 bbl.

In addition to cement, gypsum and lime, Flintkote manufactures paper products, including corrugated containers; floor coverings and adhesives; pipe and conduit; asphalt paving products and other industrial items, as well as a broad line of building products in the United States.

New UMWA Regulation

Trustees of UMWA Welfare and Retirement Fund recently adopted new regulations which tighten eligibility requirements for hospital and medical care benefits, pensions, and funeral expense and survivors benefits. Effective July 1, 1960, the regulations affect miners who have been unemployed over a year and those who have been self-employed or in any way connected with ownership, operation or management of a mine.

ALSO . . .

Southern Coal Producers Association has moved its offices from the Solar Building to Room 503, RCA Building, 1725 K Street, N.W., Washington 6, D. C.

As future cement plant sites, Marquette Cement Manufacturing Co. has purchased extensive raw material deposits at Glen Haven, Wis., and Austin, Texas, and is now in the process of acquiring a similar deposit at an undisclosed point in southern Georgia. Property for a distributing plant at St. Paul, Minn., has also been purchased. All except the Austin property are on or close to navigable waters. The company indicated that cement producing and distributing facilities will be built at these locations as soon as rising demand provides economic justification for the individual developments.

Foote Mineral Co. plans to build a $6,000,000 electrolytic manganese plant at New Johnsonville, Tenn. It will eventually produce 20,000,000 lb of manganese a year. The plant will be built in two stages with the first unit expected to be in production by late 1961 or early 1962.

The Cranberry Iron Mines in Avery County, N. C., are back in production after a lapse of a quarter of a century. Ore from the mines, now operated by Cranberry Magnetite Corp., will be converted into sponge iron and high grade steel at an electric smelting furnace, to be built within the next ten months in Carter County, Tenn. The furnace will be operated by the recently formed Cranberry Iron & Steel Corp. When the electric smelter goes into operation, Cranberry Magnetite will deliver 400 tpd of ore to it. The company is currently making shipments of 200 tpd to a plant in Rockwood, Tenn.

Contract negotiations paving the way for the construction of a natural gas pipeline between Duluth and Silver Bay, Minn., were recently completed by Reserve Mining Co., Northern Natural Gas Co., and Iron Ranges Natural Gas Co. The contracts specifically covered the proposed sale of natural gas by Northern and Iron Ranges to Reserve for its taconite plant at Silver Bay. This would mark the first use of natural gas in ore processing in this area.

OPERATORS' CORNER

(Continued from p. 67)

in mine maintenance programs. They are rapid, positive means of detecting failure before it occurs. Low cost kits can be hand-carried anywhere and operate off of 110 volt a-c or a 12-volt battery. Larger mobile equipment will handle all parts up to 100 ft away from the unit. Many objects can be inspected in place without disassembly. Defects are marked positively on the part itself. Repairs are confined to those actually needed. The integrity of salvage, repair or replacement parts is assured and the useful life of the equipment is extended. Intelligent application of these methods in a "tailor-made" maintenance program can appreciably cut the cost of inspection but, more importantly, they can cut the cost of repairs and lost production.

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Jones & Laughlin Steel Corp. has opened its new Minnesota iron ore mine. Known as the Lind-Greenway mine, it is expected to produce about 700,000 gross tons of beneficiated ore per year, or about ten percent of the company's current blast furnace requirements. The open pit operation is located on the extreme west end of the Mesabi Range near Grand Rapids.

AMC Salutes U. S. Bureau of Mines

In recognition of the U. S. Bureau of Mines' fiftieth anniversary, Julian D. Conover, Executive Vice President, American Mining Congress, wrote the following congratulatory letter to Fred A. Seaton, Secretary of the Interior:

"July 1 marks the fiftieth anniversary of the formation of the U. S. Bureau of Mines. As you well know, the American Mining Congress was one of the driving forces behind the Bureau's organization, and we look with gratification upon the record of its accomplishments over the years since 1910.

"Changes in the industry have been manifold in the intervening time, and it is to the credit of those who guide the Bureau's activities that it has kept constantly abreast of these changes, while at the same time always advancing the original goals set down by Congress when it established the Bureau. The better than ten-fold reduction in lives lost because of mine disasters, the productive research in mining and metallurgy, the valuable statistical work, and the many other activities too numerous to list stand as a tribute to its efforts.

"The American Mining Congress salutes the U. S. Bureau of Mines on its Golden Anniversary."

Secretary Seaton replied as follows:

"Dear Julian:

"Thank you for your congratulatory letter regarding the Bureau of Mines golden anniversary.

"The Department of the Interior is proud of the Bureau's many achievements and also grateful for the high esteem accorded the Bureau by such prominent and progressive organizations as yours.

"The American Mining Congress, through unfailing and enthusiastic cooperation over the past 50 years, has helped the Bureau of Mines. We hope that the Bureau's service and achievements will continue to merit your loyal support.

Sincerely yours,
Fred A. Seaton
Secretary of the Interior"

Molybdenum Corp. of America and Wah Chang Corp. plan to construct a mill in Brazil to produce columbium concentrates. Completion is expected in about a year.

The Vesta-Shannopin Coal Division of Jones Laughlin Steel Corp. is installing froth flotation equipment at its La Belle, Pa., coal preparation plant to treat material of 90 percent minus 325 mesh. New equipment includes 20 flotation cells having a total feed capacity of 36 tph at 38 percent ash. These cells are expected to recover from the slurry 16 tph of coal at 7.5 percent ash. The installation represents a major step in improving preparation plant efficiency and increasing yield.

Construction of a new plant by Hercules Powder Co. for the manufacture of commercial explosives at Gilbert, Minn., will be completed before September 1. The new facility will produce explosives especially designed for use on the Mesabi iron range.

An International Symposium on Mining Research sponsored by the U. S. Bureau of Mines and Missouri School of Mines & Metallurgy will be held at Rolla, Mo., February 22–25, 1961. The symposium will be devoted to three major areas of mining research; Explosives and Blasting; Rock Mechanics, and the Application of Basic Science to Mining Techniques.

Invitations have been issued to virtually every mining country in the world to participate. The meeting will be presented in French, German and English.

Peabody Coal Company's St. Ellen coal mine, last large shaft mine in St. Clair County, Ill., has been closed. Although St. Ellen had for a number of years produced in excess of 1,000,000 tons of coal annually, the company has found that the operation in recent years has been unprofitable. The mine has been operated for 50 years.

American Metal Climax, Inc., will construct a $7,000,000 plant in Vicksburg, Miss., to produce nitrate of potash and chlorine. Employing a new process, the plant will be operated by Southwest Potash Corp., a division of American Metal Climax. Nitrate of potash is valuable as an ingredient in many types of fertilizer, but has not been used extensively because of its high price—a situation that promises to be remedied by the new production process.

North American Coal Corp. plans to construct a 40,000 ton per year plant costing in excess of $1,000,000 to produce high purity aluminum sulphate from coal mine wastes. It will employ a new process developed under a joint program with Strategic Materials Corp. The new plant is to be located at North American's Powhatan, Ohio, mine on the Ohio River where there are extensive reserves of both coal and shale. Initial production is scheduled for June 1961.

Ideal Cement Co. will build a multi-million dollar 1,500,000 bbl a year cement plant at Fayetteville, N. C. Construction will start late this year.

International Mineral & Chemical Corp. plans to prospect for beryllium in western North Carolina. Samples containing the metal have already been mined in Spruce Pine and sold to the Government.

All of the employes of Glenbrook Colliery, Stonega Coke and Coal Co., Big Stone Gap, Va., have completed the U. S. Bureau of Mines' Accident Prevention Course.

The Mining Journal Ltd., 15 Wilson St., Moorgate, London, E. C. 2, has announced the availability of its 1960 annual review issue of *The Mining Journal* (21 shillings). Major topics include: Review of Metals and Minerals, Technical Progress, The World's Mining Fields in 1959, and Progress of Individual Companies.

American Potash & Chemical Corp. plans to construct a $5,000,000 electrolytic manganese plant at Aberdeen, Miss. The plant will have an initial capacity of 10,000,000 lb per year and will be laid out to provide for further expansions. Field construction is scheduled for fall with completion planned for late 1961.

Eastern Gas & Fuel Associates has discontinued operations at its Beards Fork mine at Beards, W. Va. Bad mining conditions were given as the reason for the closure.

National Gypsum Co. directors have authorized the acquisition of stock of Allentown Portland Cement Co. through an exchange of shares. A formal offer to Allentown's shareholders by National is expected to be made in August, following clearance with the Securities and Exchange Commission. Allentown, with cement plants at Evansville and West Conshohocken, Pa., has an annual capacity of 4,500,000 bbl. National claims to have the largest cement mill in the world at Alpena, Mich., which was included in the company's 1959 acquisition of Huron Portland Cement Co.

The coal-to-oil research branch of the U. S. Bureau of Mines in Bruceton, Pa., has received the National Safety Council's award of merit for its outstanding safety record.

Columbia-National Corp. will resume production of zirconium sponge at its Santa Rosa plant near Pensacola, Fla., by mid-June. The company, a subsidiary of Columbia-Southern Chemical Corp., has a contract with the Atomic Energy Commission.

Christopher Mining Co., Inc., of Morgantown, W. Va., has suspended operations at its Christopher Mine No. 9 due to a lack of orders. Plans for the future are uncertain.

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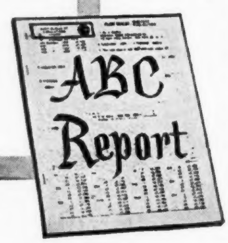

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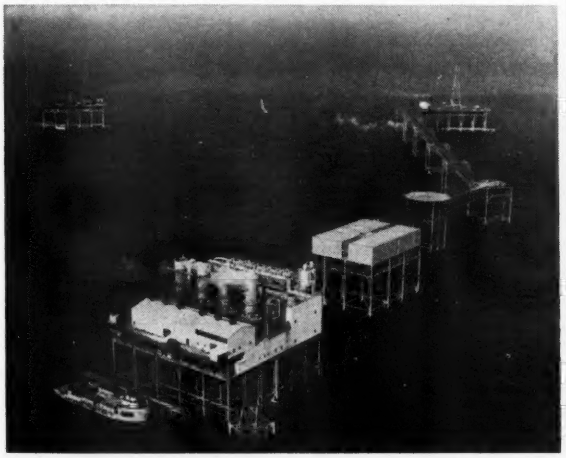
MINING CONGRESS JOURNAL

A.B.C. REPORTS — FACTS AS A BASIC MEASURE OF ADVERTISING VALUE

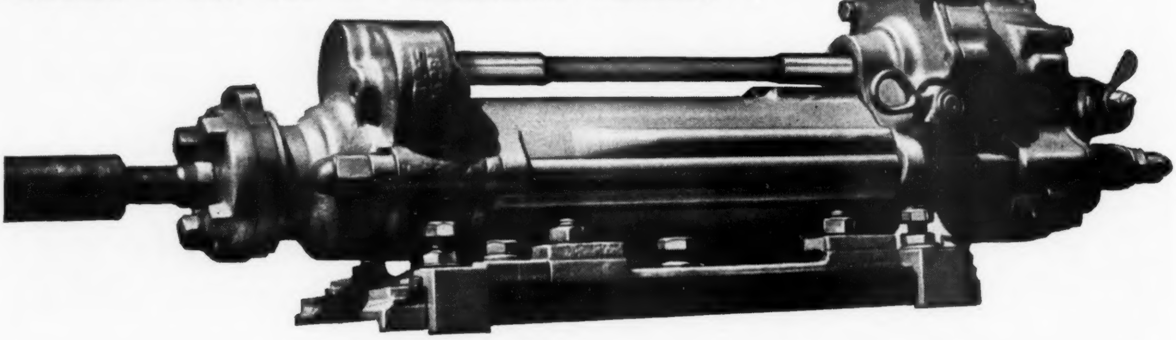
One of the newest applications for polyethylene film is its use as a seal over stoppings in coal mines. In its Robena Mine No. 3 in Greensboro, Pa., U. S. Steel Corp. is experimentally trying six-mil. polyethylene film to limit air leakage on metal stoppings used to direct vital air currents to the working face. About 100 ft of the film is used for each stopping.

The U. S. Bureau of Mines has revealed a method of forming tiny flakes of synthetic mica into paper-thin sheets that may prove superior to natural mica for certain uses in electronics. Both the new paper and the synthetic-mica flakes from which it is made are products of studies by the Bureau at Norris, Tenn., under an accelerated research program sponsored by General Services Administration.



Freeport Sulphur Co. has announced that the world's first offshore sulphur mine is now in commercial operation. Located in 50 ft of water seven miles from the Louisiana coastline, the island is the largest permanent steel structure ever erected in the ocean. It is equipped with a complex of boilers, generators, drilling and other facilities for mining sulphur from geological formations 2000 ft beneath the bottom of the Gulf. Ultimate cost of the Grand Isle project, including related facilities on shore, is estimated to be $30,000,000, of which $25,000,000 has been spent.

OPENING A NEW ERA IN PERCUSSION DRILLING...



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NEWS and views

Western

Beryllium Agreement Negotiated

An agreement providing for exploration, development, mining and concentration of beryllium minerals on a cost-plus basis has been negotiated between Beryllium Resources, Inc., and the Atomic Energy Commission of Mexico. Under terms of the agreement, Beryllium Resources will have the specific right to mine and mill beryllium under jurisdiction of the Mexican AEC, which has exclusive rights to the mineral. When the company has established adequate resources, Brush Beryllium Co., in accordance with another agreement, will join Beryllium Resources; and with the assistance of Mexico the three parties will design, build and operate a metal extraction plant in Mexico. A Mexican company, Beryllium Resources of Mexico, S. A., has been formed, and studies preliminary to full-scale geological activities have started.

Phosphate Properties Leased

J. R. Simplot Co. has acquired the phosphate products facilities of the Anaconda Co. at Anaconda, Mont., and has leased that company's phosphate properties at Conda, Idaho, on a long term basis. Simplot has been mining the Conda orebody in accordance with a joint venture agreement previously entered into with Anaconda. Announcement of the acquisition indicated that Anaconda will operate the phosphoric acid and ammonium phosphate facilities for Simplot. Simplot will continue to make the Anaconda line of fertilizers available but will do its own marketing.

Contracts Awarded for Iron Ore Project

A contract for preparation and partial construction of the Atlantic City (Wyo.) taconite mining and beneficiating project of Columbia-Geneva Division, U. S. Steel Corp., has been awarded jointly to J. H. Pomeroy & Co., Inc., and Bechtel Corp. Work to be performed under the contract will include construction of foundations for crushing, screening and concentrating plants; building about 78 miles of railroad to Winton Junction, placement of 5000 tons of machinery and 7½ million cubic yards of excavations. Arthur G. McKee & Co. will build the 4000 tpd pelletizing plant to be erected at the site. Completion of the entire project is scheduled for late 1962.

Plans Soda Ash Facility

Stauffer Chemical Co. has completed plans to begin immediate construction of a soda ash production facility with an initial capacity of 150,000 to 200,000 tons per year near Green River, Wyo. Production will be based on an extensive high-grade trona deposit which was charted during a two-year test drilling program. The project, scheduled for completion late in 1962, involves driving a mining shaft and an air shaft, building a railroad bridge to span the Green River, a railroad spur, highway and refinery. The company has developed a process to refine the as mined trona, which contains some slate and carbonaceous material, to yield top quality soda ash. The new plant will approximately double the company's current output of soda ash being produced at Searles Lake, Calif.

ALSO . . .

Exploration for trona in Sweetwater County, Wyo., will be conducted by Texota Oil Co. The company is reportedly planning to drill two 1500-ft test wells, the first of a series to be drilled in the area where it holds trona prospecting permits.

While prospecting on about 75 claims in the Clifton mining district of Tooele County, Utah, Marvel Mining Co. has uncovered what is termed a new occurrence of high grade lead-silver oxide ore. The company, which is about 48 percent controlled by English Oil Co., made its discovery while removing overburden during exploratory work on its claims.

Pacific Power & Light Co. is reported to have leased 880 acres of mining rights in the Eden Ridge coal field about 50 miles south of Coos Bay, Ore. The company has been studying the feasibility of using Eden Ridge coal to fuel a 100,000 kw steam-electric plant, and will investigate its combustion by-products and its possible use as an industrial raw material.

Production of uranium ore at the Orphan mine of Western Gold & Uranium, Inc., on the South Rim of Grand Canyon, Ariz., has been increased to 7000 tons per month. Completion of a 1500 ft shaft and 900 ft haulageway last fall obsoleted the company's 1000 ton per month aerial tramway. Since then production has been on the increase, reaching 5000 tons in December 1959 and 6500 tons in April of this year. The company is now blending its low grade ores with high grade to accommodate the Rare Metals Corp. mill at Tuba City, Ariz.

Continental Materials Corp. recently acquired one-half common stock interest in Yale Gold Mining Co., which has been exploring for silver and gold at the Elko Prince and Miners Gold properties near Midas in Elko County, Nev. As a result of the transaction, reports indicate that Continental will make about $100,000 available for continued exploration and development. Yale is a subsidiary of New Park Mining Co. and East Utah Mining Co.

A 5000-ft capacity, 1250 hp, double-drum, direct drive hoist has been ordered by Lucky Friday Silver-Lead Mines Co. for its Mullan, Idaho, mine. The hoist, which will cost about $400,000 installed, is scheduled for delivery to Lucky Friday in mid-1961. The company's present hoist is limited to operation at the 3050 level, the present bottom of the mine.

Spiral drop-cut is the term applied to a new type of operation which will replace the so-called drop-cutting method for establishing working levels and access to a new haulageway below the current pit bottom at the Bingham Canyon, Utah, mine of Kennecott Copper Corp. The new spiral tunnel approach, when it is completed in about eight months, will connect lower pit areas with a 17,951-ft tunnel driven 150 ft below the present pit bottom from nearby Copperton. The project will include excavating about 5,000,000 tons of ore below the 5640 ft level of the pit and construction of a 3600-ft railbed to connect the tunnel and pit. All ore mined below the 5840 level will eventually move downhill over the completed spiral to the tunnel, and through it to the concentrator.

Production of super purity aluminum at the Mead, Wash., plant of Kaiser Aluminum & Chemical Corp. is reportedly being tripled with installation of six 180 ton per year capacity refining cells. When the cells are placed in operation in September, the Mead plant will have capacity for producing about 1500 tons per year of the super purity material. It has also been reported that Mead is shutting down potline no. 6 which had been reactivated earlier this year. After closing the line, Kaiser's aluminum facilities will be operating at about 82 percent of its 609,500 ton per year capacity.

A copper deposit in Valley County, Idaho, will be the site of exploration by Copper Camp Co. of Boise, Idaho. The company recently executed a contract with the Office of Minerals Exploration which will permit expenditures of $34,840 at the Copper Camp mine. The Government's participation will be $17,420.

A recent amendment to Atomic Energy Commission licensing regulations concerning the use of depleted uranium by the aircraft industry has been reported. AEC, which has large

(Continued on next page)

(Continued from previous page)

quantities of depleted uranium, will now permit the use of the product for counterweights in wing tips and tails of jet aircraft without manufacturers obtaining the customary licenses for receipt and possession. It is said that about 300 lb of metal used in a single jet airliner will improve aircraft performance and economy over other materials now employed.

A 10 by 16 ft rod mill has been placed in operation on a test basis at the Arthur mill of Utah Copper Division, Kennecott Copper Corp. The rod mill, presently handling about 3700 tpd of ore, will be tested for about a year under a program aimed at solving crushing and grinding problems involving coarse copper ores from the company's Bingham Canyon mine. If the results are satisfactory, rod mills will probably be installed to replace the present rolls.

A one-mile tunnel that connects the Castle Gate and Kenilworth coal mines of Independent Coal & Coke Co. in Carbon County, Utah, has been completed. The $300,000 project, which included laying 3½ miles of new track, will, in addition to lowering operating overhead, eliminate freight charges previously incurred in moving coal from the Kenilworth mine to a utility plant at Castle Gate. The company will place outside facilities at the Kenilworth on a standby basis.

The largest shipment of uranium ever made from the United States for overseas civilian use recently left Oakland, Calif., for West Germany. Valued at about $3,000,000, the shipment consists of 100 nuclear reactor fuel elements weighing about 7½ tons for West Germany's first nuclear power station.

A 60 to 100 tpd lime plant will be built at the Ray Mines Division concentrator of Kennecott Copper Corp. at Ray, Ariz. It will produce milk-of-lime for use as a conditioning agent in the concentrator's flotation circuit.

A two-year prospecting permit on about 120,000 acres of the Fort Apache Indian Reservation in eastern Arizona has been granted to the Colorado Fuel & Iron Corp. CF&I, following up on two years of preliminary geological studies, seeks to determine whether or not iron ore deposits in the area involved justify development. Large scale mining operations would necessitate bringing a railroad 40 miles into the area.

wheels of government

(*Continued from page 70*)

An identical measure by Rep. Baker (Rep., Tenn.) was approved by the Ways and Means Committee and is pending in the House.

The fate of this legislation is clouded by the politically charged atmosphere of the Congressional wind-up.

COURT SUPPORTS CLAIMHOLDER IN POWER SITE CASE

A California Federal District Court has held, in effect, that the owner of mining claims located on land later withdrawn for power purposes did not forfeit his claims when he failed to file for record in the U. S. district land office within one year after the effective date of the Mining Claims Restoration Act of 1955.

This case hinged on interpretation of language contained in that Act. While it requires timely filing for record of notices of location, this law provides no penalty for failure to file, and further provides that nothing in it "shall be construed to limit or restrict the rights of the owner or owners of any valid mining claim located prior to the date of withdrawal or reservation."

The plaintiff in this case did not record his claims within the one-year period allowed by the Act. Subsequently the Solicitor of the Interior Department, in an opinion dated October 30, 1957, declared, "Failure to file as required results in a forfeiture of the claim." The plaintiff then brought suit to procure an injunction restraining Bureau of Land Management officials from issuing any notice declaring plaintiff's mining claims forfeited, or clouding their title.

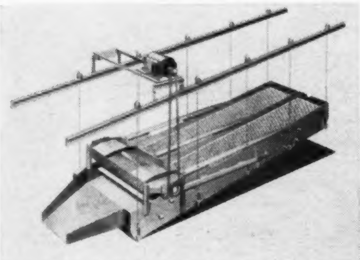
The Court granted summary judgment in favor of the plaintiff. In its memorandum, the Court stated: "The Solicitor takes the position that the Act would prevent the restriction or limitation of claims, such as plaintiff's, but would not preclude their complete destruction. It is completely unrealistic to assume that Congress would exert itself to avoid limitation or restriction of such claims, and at the same time be quite willing to permit them to be destroyed entirely. A prohibition of limitation or restriction carries an implied prohibition of destruction. To destroy a legal right is to limit it to the smallest possible compass. It is in fact the greatest possible restriction. To declare plaintiff's claim forfeited would clearly violate the plain mandate of Congress."

WESTERN NEWS (Cont.)

Texas' first and the nation's 26th uranium ore processing plant will be built by Susquehanna-Western, Inc., near Falls City in Karnes County. The company recently signed a uranium purchase contract with the Atomic Energy Commission which provides for erection and operation of a 200 tpd mill estimated to cost $2,000,000. Slated for completion early in 1961, the mill is expected to treat uranium bearing ores from Karnes County deposits where the company has mining leases. The contract with AEC, which runs to December 1966, further reserves a portion of the mill for production from independent ore producers in the area who had reserves developed prior to November 24, 1958.

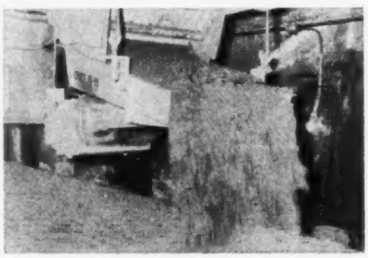
manufacturers forum

A SHAKER SCREEN that follows the trend to compactness has been announced by Fairmont Machinery Co., Fairmont, W. Va. The screen drive has been integrated to eliminate drive



arms and provide extra space for screen capacity. The drive and screen are suspended from wire rope. Drive mechanism of the shaker screen is an enclosed self-contained unit with forced lubrication and all anti-friction bearings. Units are furnished with the desired stroke and speed ranging from ½ in. at 1000 rpm to 5 in. at 165 rpm. Speed and stroke can be adjusted and varied. Power is supplied by a three-phase induction motor.

THE VIBRATORY FEEDERS of the Hi Vi line from Eriez Co., Erie, Pa., now include a heavy duty unit, the 75 A, designed to handle a great diversity of materials in a wide range of particle sizes. It has a rated output



of 75 tph when operating level. It is available as either a suspended or a base mounted unit. Working on a push-pull principle the 75 A has an Eriez electro-permanent magnetic drive system which operates directly from alternating current and needs no rectifier. Drive elements are completely enclosed.

COMPLETION OF A GAMMA-RADIOGRAPHIC inspection room has been announced by the Farrell-Cheek Steel Co., 110 Lane St., Sandusky, Ohio. The installation is based on the use of the radioactive isotope cobalt 60 as the energy source in making gamma-ray exposures on film through sections of steel castings. Purpose of the inspection facility is to maintain a high degree of quality in the company's electric furnace carbon and alloy steel castings. Farrell-Cheek products include mine car wheels, wheels and rollers, elevator and conveyor parts, sheaves, wire rope fittings and shovel parts.

"ONE USE BITS" for dustless vacuum type drills have been developed by Western Rock Bit Mfg. Co., Salt Lake City, Utah. The WRB Tee Cee type TCVA or TCVB is a shallow tungsten-carbide insert bit for either class A or class B taper connections. The bit reportedly needs no resharpening and it has been designed with low-cost footage in mind. The WRB type SLVA or SLVB bit is a low-cost "used to destruction" steel bit of which the outstanding feature claimed is its pilot construction and wing design. Both types of bits are of five-hole design and are interchangeable.

THE ELECTRIC SUBMERSIBLE PUMP, Model B-38L of Flygt Corp., Hoosick Falls, N.Y., is now being offered in a 110-volt version equipped with 1.8-hp motor. With capacities to 85 gpm, and heads to 90 ft, this model draws only 13 amp which allows it to be operated from most house currents and portable light plants.

A PRIMER-INITIATOR, designed for ammonium nitrate-fuel oil blasting agents, has been developed by Chromalloy Corp's Propellex Chemical Division, Edwardsville, Ill. Known as the Saf-T-Boost Initiator (Model 151) it is said to require no tying, splicing, or taping and is reportedly suitable for decking, stemming, or any other blasting technique. Economy and safety are two advantages stressed by its developers. It is packaged in a cardboard container, and weighs 13 oz, is 3 in. in diam, 2 in. high. The initiating cord is threaded through two ¼-in. holes. Primer delivers a detonation velocity of over 20,000 fps.

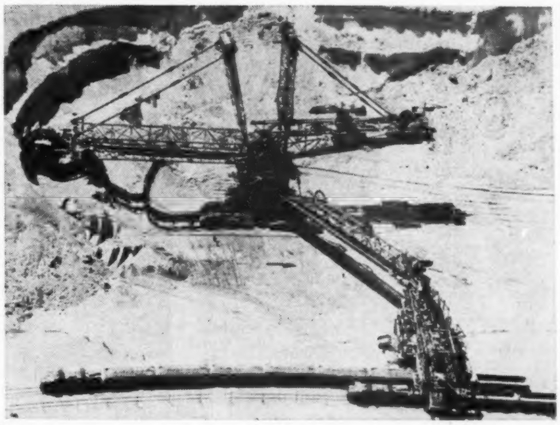
A CRAWLER-MOUNTED DRILLING UNIT, the G-900 Tracdril is said by its manufacturer, Chicago Pneumatic Tool Co., New York, N. Y., to be an advanced piece of one-man mechanized drilling equipment. Capable of drilling over either track at right angles, and of drilling horizontal snake-holes a scant 25 in. from the ground, the drill's boom can be raised to a height of 11 ft for horizontal breast-holes and the carriage dump adjusts through a full 360° to increase top-hole reach.

ALUMINUM ELECTRICAL CONDUITS, designed to suit installations requiring light-weight, corrosion-resistance and easy bending, are being produced by National Electrical Division, H. K. Porter Co., Inc., Porter Bldg., Pittsburgh, Pa. The conduit is made of prime aluminum alloyed to grade number 6063 and processed to a T-42 temper to provide high ductility and permit close dimensional control of the conduit during manufacture. It is available in all sizes ranging from ½ through 6 in. diam. Each length measures ten ft when a coupling is attached.

USABLE BOTH AS A STANDARD DESK AND AS A DRAWING TABLE, the Drawing Chief is available from Densmore Calculator Co., 2003 E. Fourteenth St., P. O. Box 1557, Oakland 4, Calif. Drawing board

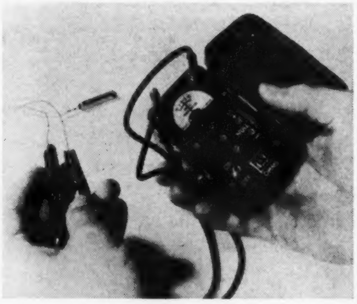
is concealed under desk top and elevated into posture chair height by a raising mechanism when desk top is opened. When closed, drawing board fits into a well with enough clearance between it and desk top for permanent mounting of drafting machine. There is adequate storage space for tools, books, paper and supplies.

A MATERIALS HANDLING SYSTEM that uses prestressed concrete channels as the conveyor support has been announced by Frank J. Madison Co., 112 Market St., San Francisco 5, Calif. In this design, the U-shaped beams are inverted so as to also serve as a protective cover for the belt, drive, idlers and the material being handled. Advantages claimed include lower initial cost and less maintenance. It is said that permanance in any environment can be expected from this design, the use of concrete being especially advantageous in normally corrosive atmospheres.



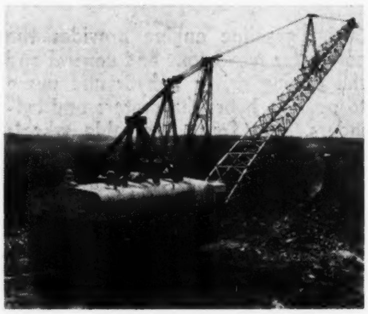
THE LMG BUCKET WHEEL EXCAVATOR, for which sales rights in United States and Canada have been acquired by Link Belt Co., Chicago, Ill., is built in sizes to dig from 200 up to 13,000 cu yd an hour. The rotating digging wheel, which has buckets on its periphery, is used in open-pit mining operations for large scale removal of earth, overburden, sand, gravel, certain ores and lignite. The wheel, located at the end of a boom, scoops up overburden and drops it upon a conveyor within the machine and thence to other conveyors to cars. The entire assembly is mounted on self-propelled crawlers. Link-Belt will sell the machine in conjunction with its most recent line of high speed, high capacity belt conveyors. The LMG excavator is manufactured in West Germany by Orenstein-Koppel and Lubecker Maschinenbau AG.

A VERTICAL LIFT MOUNTED ON FOUR RUBBER-TIRED WHEELS has given the bridge crane new maneuverability according to designers at Travelift & Engineering Inc., Sturgeon Bay, Wis. In this arrangement, the front wheels can be steered enabling these units to go wherever a lift is needed. In a typical 25-ton-capacity model (as pictured here) a 60-hp gasoline engine provides the power for movement and control and the engine drives a hydraulic pump to operate hydraulic motors and cylinders. The front, steerable wheels are also the drive wheels. Each wheel is chain driven by a speed reducer, which is driven by a hydraulic motor. Motor and reducer are mounted on brackets to the wheel axle supports.



A POCKET SIZED TESTER to check explosive igniters, detonators, primers, or squibs has been developed by Kinetics Corp., Solana Beach, Calif. A sensitive bridge circuit is used, and maximum test current is limited to ten milliamperes, reportedly eliminating danger of setting off igniters during the test. Its power source is a self-contained battery, and the weight of the whole unit is less than one lb.

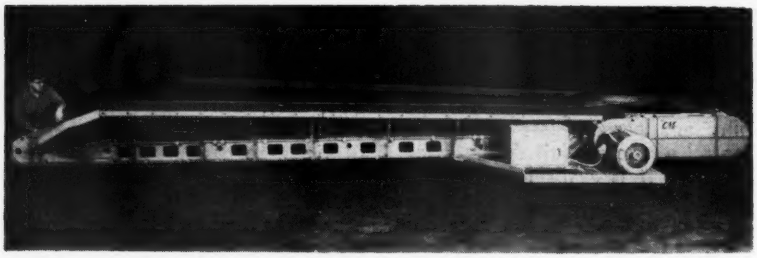
THE DIESEL WALKING DRAGLINE, Model 732 of the Page Mfg. Co., Chicago, Ill., swings a 16 cu yd Page Dual Hitch Automatic Dragline Bucket and



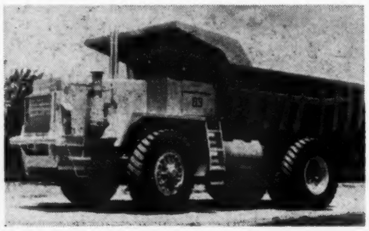
carries a 200-ft boom. It is powered by twin V-6 diesel engines, said to be the only diesel engineered and developed exclusively for dragline machines. The bucket adjusts at any desired depth above or below the fairlead.

A SIGHT GRAVITY-FEED OILER (Style EVO) has been announced by Gits Bros. Mfg. Co., 1866 S. Kilbourn Ave., Chicago 23, Ill. Among the precision features incorporated into this unit, according to the manufacturer, are a needle valve adjustment for lubrication control accuracy; a toggle lever shut-off, located to tell a maintenance man many yards away whether unit is in operation; uninterrupted metering of oil by adequate venting; and a sight feed window for checking the oil delivery rate. It is available in both glass and unbreakable plastic in six standard sizes.

A CHAIN FLIGHT CONVEYOR used to load belt conveyors has been introduced by Mining Equipment Div., Columbus McKinnon Chain Corp. Tonawanda, N. Y., in two new sizes for use in thin seams down to 30 in. in thickness. Known as Ratio-Feeders, these units complete a line that ranges up to 15-tons storage capacity. They take material from the shuttle car at the car's highest discharge rate and meter it at a controlled rate to the belt. Additional functions of these units are prevention of belt overloading, spillage and damage. The new RF-40 series features 24 in. and 30 in. over-all height with capacities from $2\frac{1}{4}$ to $3\frac{1}{2}$ tons.



AN END DUMP TRUCK, the model 40 SL, with 40-ton capacity has been introduced by K-W Dart Truck Co.,



Kansas City, Mo. The vehicles are 30 ft long, 13 ft high and 12 ft wide, and are powered by a V-12 diesel engine coupled with a four-speed transmission-converter. Tires, front and rear, are 18.00 by 33.

A GEAR DRIVE, said to be a compact space saver drive arrangement for grinding mills, has been developed by engineers of Allis-Chalmers Mfg. Co., Milwaukee, Wis. Called the Twinducer, it harnesses the power of two

synchronous motors located on the mill side of the drive. The electrical load is distributed through an angular rotor shift of one of the motors. Once the load is balanced and the rotor locked in place, no further adjustment is needed, according to the manufacturer, nor are floating gear or pinions required.

A LOCKERBASKET, featuring both self-locking garment hooks and the patented Sur-Hold coat hanger with vertical coat stabilizers, has been introduced by The Moore Co., 1036

Quarrier Street, Charleston, West Va. The coat hanger permits garments to hang naturally, exposed to circulating air, while providing safety against their falling when the unit is in an elevated position.

ANNOUNCEMENTS

Robert B. Bradley, president of **International Harvester Co. of Canada, Ltd.,** has been elected to the office of vice president and executive head of the company's **Construction Equipment Division.** He succeeds **Harald T. Reishus,** retired.

R. B. Bradley

Bradley, who joined International Harvester in 1929, has served the organization in many managerial capacities in this country and in Australia as well as Canada. He has held his Canadian post since 1954.

Leschen Wire Rope Div., H. K. Porter Co., Inc., has opened a district office and warehouse in Oklahoma City, Okla., at 216 South Klein St., to service the sales district embracing Oklahoma, Texas, Kansas, Nebraska, Colorado, Wyoming, and South Dakota.

V. L. Snow has been appointed general manager of the **Euclid Division** of **General Motors Corp.** He has been with Euclid since 1935 in a variety of sales and engineering positions and was director of engineering when appointed to his new position. In the new assignment he will be responsible for the administration of the four Euclid plants in Cleveland, the crawler tractor plant at Hudson, Ohio, and operations of Euclid (Great Britain) Ltd. in Scotland.

William J. Loudermilk, Jr. has been named sales representative in southern West Virginia for **Long-Airdox Co.** Loudermilk, a veteran of 13 years with **Eastern Gas & Fuel Associates,** joined Long-Airdox in April.

Robert L. Johnson has been named foundry manager for **Hardinge Mfg. Co.,** York, Pa. In his new position, Johnson will direct all activities of the company's "Meehanite" and "Ni-Hard" Foundry, where a $300,000 expansion and modernization program is nearing completion. He came to Hardinge in April of this year from **Bucyrus Erie Co.** in Erie, Pa., where he had been general foreman of the Iron Foundry.

Three appointments for the Bluefield, W. Va., district of the **Jeffrey Mfg. Co.** have been announced: **P. M. Campbell** as assistant district manager; **Milton Harper** as Apparatus sales engineer in the No. 133 (N&W) territory; and **Court Clarke** as Renewal Parts sales engineer in the Beckley territory.

Paul Johnson, sales engineer for **Goodman Mfg. Co.** in northern West Virginia for the past several years, has been moved to Chicago as manager of technical training. He is replaced by **Harold Nordness,** who has been sales engineer in Illinois.

Eimco Corp. has announced the election of two of its executives as vice presidents plus the creation of a new position of financial vice president. Sales manager **Wayne L. Dowdey** and **Dr. Don Dahlstrom,** director of the company's Palatine, Ill., Research and Development Center, were elected to vice presidencies and the new financial post has been given to **T. F. Olson,** formerly a comptroller for **Crane Co.**

Max Rae Ahrens has been assigned by **Climax Molybdenum Co.** to the Denver office to serve as assistant manager of abrasion resistant alloy development. Ahrens was previously located at the company's operations in Climax, Colo., where he was resident physical metallurgist.

John P. Steel has been appointed as assistant to the sales manager of the **Mining Tool Division** of **Kennametal Inc.,** Bedford, Pa. He had been in the company's advertising department since 1955.

Edmund A. Bowman and **Robert L. Young** have joined the **Ferndale** installation of **Allegheny Ludlum Steel Corp.,** where they will serve respectively as production field engineer of the **Carmet Division** and as buyer for the purchasing department. Bowman joined Allegheny from **Brunner & Lay, Inc.,** and Young came to his new job from the **Ethyl Corp.**

E. A. Bowman

CATALOGS & BULLETINS

ELECTRIC WINCH-HOIST. *City Engineering Co., Inc., 3547 Massachusetts Ave., Indianapolis 18, Ind.* Nine ways to use the 60-lb My-Te portable electric winch and hoist are shown in bulletin M-60. Designed to lift 2500 lb and pull 5000 lb, the unit mounts on truck, car, or boat with six bolts. It works off any 6 or 12-volt battery.

CRAWLER TRACTORS. *The Eimco Corp., P. O. Box 300, Salt Lake City 10, Utah.* Bulletin L-1097 covers the company's line of 100-hp diesel Eimco 103 crawler tractors. Included are full specifications on the tractor, bulldozers, front end loaders and log loader units in this series. In addition, there are schematic drawings and coded listing of performance and other features.

MAGNETIC SEPARATOR. *Carpco Mfg., Inc., P. O. Box 3272, Jacksonville 6, Fla.* Bulletin RFB-102 describes a permanent rotating field laboratory magnetic separator known as Model RF-1660. The compact unit, is equipped with a vibrating feed hopper attached to a pan formed into a downward volute curve which "curtain feeds" the material to be separated under a cylindrical stainless steel housing, inside of which are permanent magnets rotating on a hub in a direction counter to the downward fall of the material. This type of separator was developed particularly to remove magnetite and other highly magnetics from granulated materials in the dry state.

BELT CONVEYOR IDLER. *Barber-Greene Co., Aurora, Ill.* Catalog covers idler application and describes and illustrates the more than 800 units in the complete Barber-Greene line. Features of four different series, designed to match a variety of jobs and conditions, are discussed, and complete specifications and weights for each unit are listed.

SINGLE ROLL CRUSHER. *Pennsylvania Crusher Div., Bath Iron Works Corp., West Chester Pa.* Bulletin 2020 describes the Pennsylvania "Hercules" single roll crusher, which the company recommends for heavy duty primary or secondary crushing of such materials as cement rock, gypsum, mine refuse, coal with rock in it, muddy materials, limestone, ores, shale and slag.

PLUG-IN BUS DUCT. *Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30, Pa.* Application Data No. 30-661 is complete with descriptions, drawings, dimensions, specifications, engineering and test data to give the specific information needed to lay out, specify and install the plug-in bus duct.

DUST SEPARATORS. *The Day Co., 810 Third Ave., N. E., Minneapolis 13, Minn.* Performance data, installation photos, selection and dimension charts for Dual-Clone dust separators and Dual-Clone supports are given in Bulletin D-20. These separators utilize the basic principles of dust separation by cyclonic action plus patented internal "skimmers" which produce a two-stage separation. They have no moving parts and can be furnished in 22 standard sizes to handle air volumes from 250 cfm to 23,750 cfm of air.

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MAST FOR LIFT TRUCKS. *Advertising Dept., Yale & Towne Mfg. Co., Yale Materials Handling Div., 11,000 Roosevelt Blvd., Philadelphia 15, Pa.* Specifications of Yale Triplex masts, which are now available for use with 2000–3000 lb capacity versions of Yale Series GP-52 gasoline-powered, and K-46, K-47, and K-58 electric industrial lift trucks, are included in Yale Bulletin 2410A. Various construction features and operating characteristics of the mast are also covered. The Triplex mast is an extra-high lift, hydraulically-operated unit with normal collapsed-mast height headroom clearance.

SAFETY WORK GLOVES. *Advance Glove Mfg. Co., 901 W. Lafayette Blvd., Detroit 26, Mich.* Catalog describes gloves of every style and fabric. Included are gloves that are resistant to water, chemicals, oil, and heat.

DRILLING ROCK WITH COUPLED STEELS. *Thor Power Tool Co., 175 N. State St., Aurora, Ill.* Bulletin No. 10815 discusses and illustrates proper operational and maintenance procedures for coupled rock drill steels, including such topics as correct rotation, drill, and feed control operations; starting a hole; proper feed, drilling and lubrication practices; adding and removing steels; bit maintenance, and dust control.

STEEL CONVEYOR PULLEYS. *Multiple V-Belt Drive & Mechanical Power Transmission Association, 27 E. Monroe, Chicago 3, Ill.* A new standard entitled "Welded Steel Conveyor Pulleys—Recommended Load Ratings for Standard Pulleys" has been published. It includes a tabulation of load ratings applicable to standard welded steel conveyor pulleys, a list of the pulley diameters considered standard for the industry, and a list of pulley face widths which are standard for the industry. Also included are several pages of data helpful to the engineer in selection of the proper pulleys. Copies may be obtained from any manufacturer of welded steel conveyor pulleys or they may be obtained at the price of $1.00 from Multiple V-Belt Drive & Mechanical Power Transmission Association.

WORM GEAR DRIVES. *Foote Bros. Gear and Machine Corp., 4545 South Western Blvd., Chicago 9, Ill.* Engineering Catalog HGB, illustrating and describing the complete line of Foote Bros. enclosed worm gear drives, features simplified selection procedures and rating tables to facilitate identification of the drive which meets a specific requirement.

UNITIZED CONVEYOR-SCALE SYSTEMS. *Weighing & Control Components, Inc., 822 E. County Line Road, Hatboro 10, Pa.* Bulletin 60 covers the use of conveyor-scale systems for flow-rate control and total thru-put measurement of bulk materials.

CUTTING EDGES. *Caterpillar Tractor Co., Peoria, Ill.* Entitled "Best by Job Test," Form 33708 describes how cutting edge costs can be reduced. Featured in the booklet are reports from scraper and dozer owners across the country who have used various types of cutting edges in material ranging from rock and gravel to highly abrasive sand. Benefits of induction-hardened edges are cited as well as features and benefits of multi-section dozer and scraper edges.

EXPLOSIVES STRIPPING. *Atlas Powder Co., Wilmington 99, Del.* A reprinted article, "Moving Overburden with Explosives" explains how careful planning and use of ammonium nitrate blasting agent in combination with millisecond delay electric blasting caps moves up to 40 percent of a stripping operation's overburden without the use of equipment. Savings are discussed and suitability of this method for other strippings is outlined.

POWER TRANSMISSION MACHINERY. *Dodge Mfg. Corp., Mishawaka, Ind.* Catalog describes all products in the company's line of mechanical power transmission equipment. Sections of the book are devoted to both new and established product categories, with engineering drawings, dimensions, weights, prices, technical data in tabular form, and selection and application information. Requests should be made on company letterhead.

HANDBOOK ON WIRE ROPE AND SLINGS. *Union Wire Rope Corp., 2144 Manchester Ave., Kansas City 26, Mo.* Cartoon caricatures liven up and aid illustration of a 28-page booklet on abuses that shorten the life of wire rope and on the correct way to use wire rope and slings to add to their service life.

CIRCULAR SLIDE RULE. *General Industrial Co., 1760 W. Montrose Ave., Chicago 13, Ill.* Your business letterhead and duties as an engineer or executive will bring you free of charge a circular slide rule which this company has just started producing. It is pocket-size and claimed to be quick and easy to operate. For those not qualified as engineers or business executives the instrument can be purchased for fifty cents.

Index to Advertisers